For Editorial Contents see page 361

PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

Engineering Library

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 149—No. 3873. LONDON: FRIDAY, APRIL 5, 1940. Registered at the General Post Office as a Newspaper PRICE 1s. BY FOREIGN POST 1s. 2½d.

APR 20 1940

Air Receivers Buoys, Road Wagons Tanks. **TANKS** Hoppers, Chimneys, Ducting.
EVERYTHING FROM MILD STEEL PLATE.
JOHN BELLAMY
EAST 1892 LIMITED Est. 1860
MILLWALL E.14 1216

J. & E. HALL REFRIGERATION
FOR LAND & MARINE PURPOSES
LIFTS AND ESCALATORS
J. & E. HALL LTD., ENGINEERS, DARTFORD, KENT.
Telephone: Dartford 3456.
London Office: 10, ST. SWITHINS LANE, E.C.4.
Telephone: MANSION HOUSE 9811. 755

PATTERNS
B. LEVY & CO. WOOD & METAL. Osbert St., S.W.1 Vic. 1073

METAL SLITTING SAWS
GROUND FLAT STOCK
WILLIAM WARD & SON (SHEFFIELD) LTD. CENTENARY WORKS, WOODSEATS ROAD, SHEFFIELD. 712

SECTIONAL PRESSED STEEL TANKS
also
RIVETED and WELDED PLATEWORK
STORAGE TANKS, BUOYS, CHIMNEYS
BUNKERS, HOPPERS, Etc.
BROWN, LENOX & CO. (LONDON) LIMITED.
Contractors to the Admiralty since 1808
MILLWALL LONDON, E.14
Telephone: East 0700/1 9882

LA MONT WASTE-HEAT BOILERS
Particulars from:—
LAMONT STEAM GENERATOR LTD.
Quadrant House, 55, Pall Mall, London, S.W.1. 677

FOR HIGH CLASS
PATTERNS & MODELS
Phone: EUSton 3176 (4 lines)
GEORGE WAILES & CO. LTD.
382-8, EUSTON RD., LONDON, N.W.1.
Specialists since 1855 669

LOCOMOTIVES
STEAM OR DIESEL
HUDSWELL CLARKE & Co. LTD.
RAILWAY FOUNDRY, LEEDS.
London Office: 46, Victoria St., S.W.1.
Telephone: Victoria 1133 8559

SPENCER - BONECOURT
Patent Waste Heat Boilers
32, Farringdon Street, London, E.C.4. 868

YARROW
& CO. LTD.,
GLASGOW
SHIPBUILDERS
MARINE ENGINEERS 848
LAND AND MARINE BOILER MAKERS

PETER BROTHERHOOD
PETERBOROUGH LTD.
STEAM ENGINES AND TURBINES,
GAS AND OIL ENGINES,
AIR COMPRESSORS,
REFRIGERATING PLANT,
See advertisement, Page 27. 6938

SPRINGS
FOR ALL PURPOSES 688
WILLFORD & CO. LTD.,
PARK · HOUSE WORKS, SHEFFIELD, 9

DREDGERS
OF ALL TYPES
FERGUSON BROS. (Port-Glasgow) LTD.
PORT-GLASGOW. 626

FORGINGS.
WALTER SOMERS, LTD.,
HALESOWEN 7116

WAGONS
HURST, NELSON & CO., LTD.,
MOTHERWELL 3382

SPECIAL MACHINES
MADE TO ORDER
Parts and repairs
Erection of Plant
Millwrights work 952
THOMAS HUNT & SONS
Bridge Road West BATTERSEA, S.W.11.

PULLEYS
BARRY, HENRY & COOK, LTD. 789

LIGHTALLOYS LTD.
FIRST QUALITY
ALUMINIUM CASTINGS
ALPAX WORKS, St. Leonard's Road, Willesden Junction, London, N.W.10. Telephone: Willesden 3460-1-2. Telegrams: "Lightalloys-Phone-London."

WATER SOFTENING
PATERSON ENGINEERING CO., LTD.,
83, KINGSWAY, LONDON 780

Research Engineers, Ltd., Northampton Grove, Canonbury, London, N.1. Design and construction of mechanical and electrical machinery and apparatus. Experimental work of any description. We have also a department for quantity production on completion of experiments. 794

BABCOCK

RAPIER
Builders of Europe's Largest
EXCAVATORS
RANSOMES & RAPIER, LTD
IPSWICH 548 ENGLAND

CRADLEY BOILERS
CRADLEY BOILER CO., LTD., 639
CRADLEY HEATH, STAFFS.

MUREX Electrodes
625
MUREX WELDING PROCESSES LTD.,
HERTFORD RD., WALTHAM CROSS, HERTS.

MACROME
—Toughest Tools in the World—
MACROME LIMITED 842
Hay Mills, Birmingham. Telephone: Vic. 1283
"Z Dept."

CRANES
GEORGE RUSSELL & CO., LTD.,
Motherwell. 816

Available for immediate delivery, 5 tons STEEL CHECKER PLATES, 12 ft. by 8 ft. by 4 ft., excellent condition.—Apply, METAL UNION, LTD., 96, Victoria Street, S.W. K 108

25 tons of Bright Steel BOLTS and NUTS. DELIVERIES FROM STOCK. Write for detailed list.—WM. HURLOCK, JUNR., LTD., A.C. Works, High Street, Thames Ditton, Surrey. K 134

For Sale, secondhand 7 ton STEAM-DRIVEN CABLEWAY, 1,050 ft. span, 95 ft. masts luffing 15 ft. both sides from centreline, just completed bridge contract.—Apply, HENDERSONS, Kings Works, Aberdeen. K 139

Wanted, Portable Steam ENGINES, all sizes, ALSO GARRETT LOCOMOBILE SETS.—FRED WATKINS, Coleford, Glos. J 758

Alfred Herbert Ltd., Coventry PAY BEST PRICES for SECONDHAND MACHINE TOOLS in good condition, by first-class makers.—Write, wire, or phone, and our representative will call. 'Phone 88781 Coventry. Telegrams LATHE, Coventry. W 305

VALVE
866

Send for NEW Catalogue
COOPER SPLIT ROLLER BEARINGS
KING'S LYNN 708 NORFOLK

TWIN DISC CLUTCHES
BRITISH TWIN DISC & CLARIFIERS LTD.,
BUSH HOUSE, ALDWYCH, LONDON, W.C.2

WATER SOFTENERS
JOHN THOMPSON
(KENNICOTT WATER SOFTENERS) LTD.,
WOLVERHAMPTON
Estd. over 40 years. 744

TAYLOR AND CHALLEN POWER PRESSES
TAYLOR AND CHALLEN LIMITED. 718
DERWENT WORKS, BIRMINGHAM, 19.

VISCO
AIR FILTERS
DUST COLLECTORS
COOLING TOWERS 8384
THE VISCO ENGINEERING CO., LTD.,
Stafford Road, Croydon. Phone: Croydon 4181/5

SAMUEL PLATT
LIMITED
King's Hill Foundry, Wednesbury, Staffs.
DRAWBENCHES
FOR
AIRCRAFT WORK 699

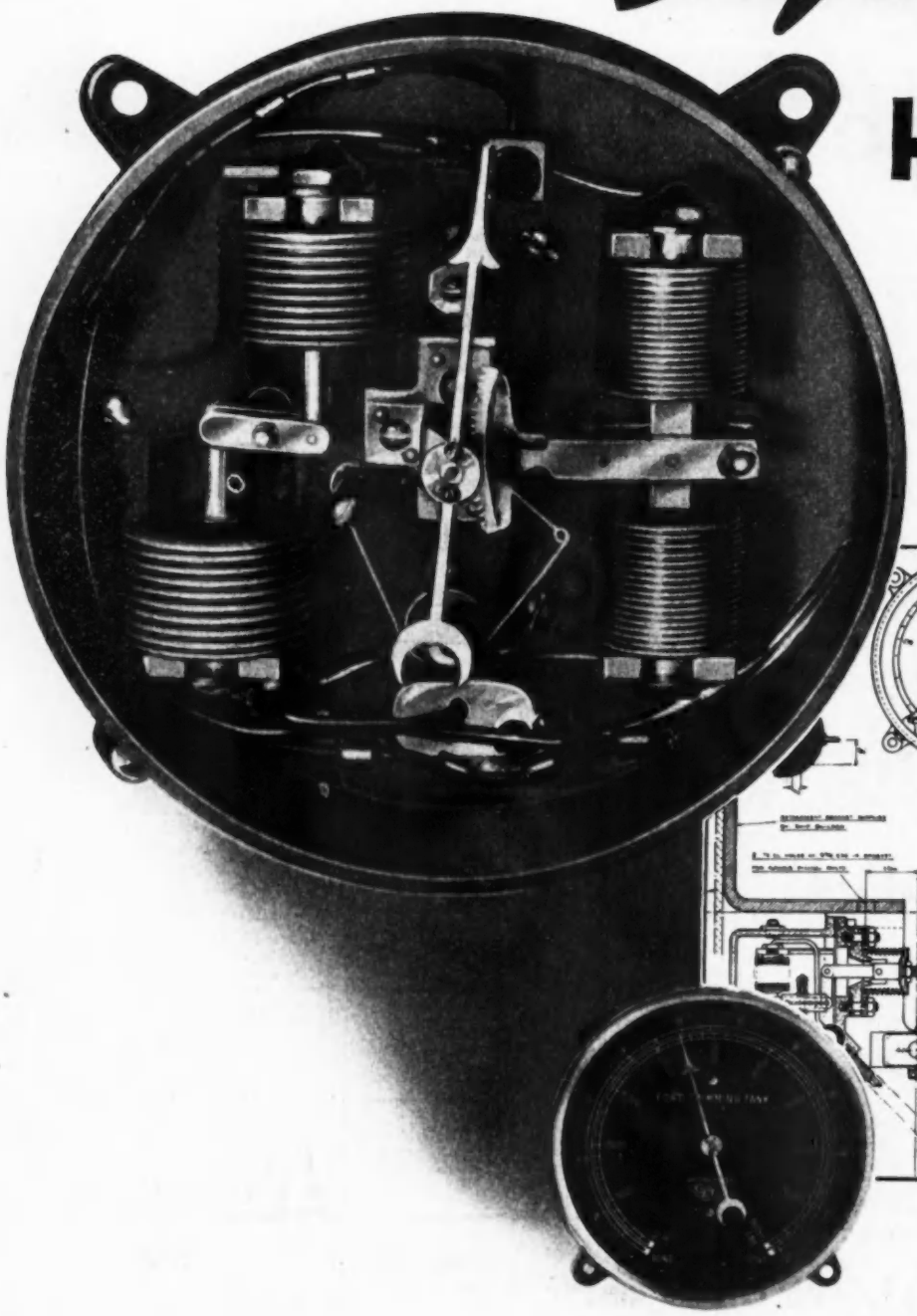
ALLDAYS & ONIONS
685 BIRMINGHAM. LTD.
FOUNDRY PLANT

"The machine with a BRAIN"
SCIAKY
SPOT WELDERS
SLOUGH —— 22342

WATER TURBINES
GILBERT GILKES & GORDON LTD.,
KENDAL, ENGLAND. 787

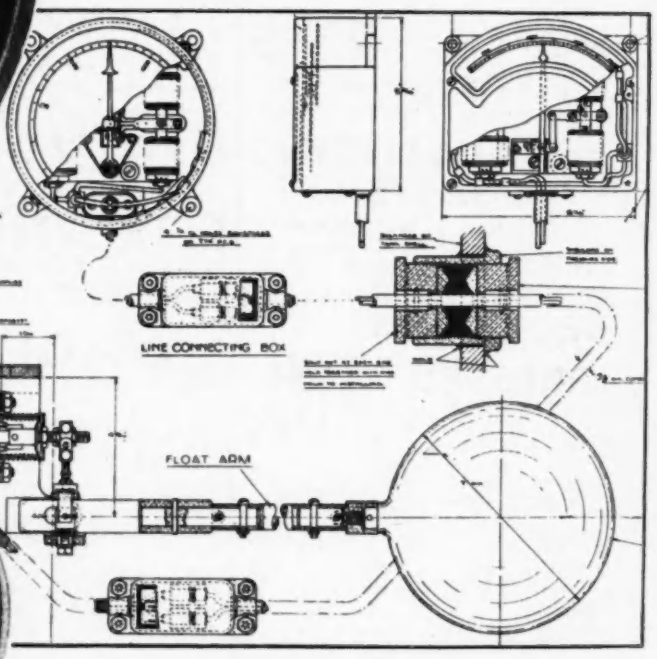
VALUE

Liquidometer



HYDRAULIC GAUGE

AN SA PRODUCT



Designed to indicate exactly the contents of a distant tank, the Liquidometer Hydraulic Gauge gives continuous readings without batteries, compressed air or manual operation. Variations in temperature and pressure are automatically compensated and leave the accuracy unaffected. No lubrication, replenishment or servicing are required. The tank unit is sealed and entirely leak-proof.

The Liquidometer Gauge employs the principle of a balanced hydraulic circuit. Adaptability and ease of installation are exceptional, whilst the construction throughout conforms to the best engineering practice.

SIMMONDS AEROCESSORIES LTD
GREAT WEST ROAD, LONDON.

Longleys

PENSTOCKS FOR HYDRO-ELECTRIC POWER PLANTS.

By P. J. BIER.*

A PENSTOCK, as defined in the glossary for hydraulics issued by the American Society of Civil Engineers, is a closed conduit for supplying water under pressure to a water wheel or turbine. This definition is repeated here to clear up the confusion which seems to exist relative to the proper meaning of the word. Penstocks may be constructed from wood staves, reinforced concrete, cast-iron or steel pipe. For the higher-head developments, steel is used almost exclusively, and this article will be limited to a discussion of steel penstocks. Penstocks may be located in tunnels or above the ground, depending on the nature of the installation. Where the power house is located directly below the dam, as at Boulder, and where diversion tunnels are provided, these can often be utilised later for the installation of the penstocks. The penstocks may also be run through the dam and concreted in solidly, as at Grand Coulee, Seminoe, or Marshall Ford dams. Running penstocks through a dam or tunnel has certain advantages over installations in the open, as the penstocks are protected from climatic changes, which tend to increase the temperature stresses in the steel and require provision for expansion and contraction, anchorage, and expensive supports, especially over ground of varying profile. Installations in dams, however, interfere with concreting work and are less accessible for inspection and maintenance. The question may be asked, why a steel penstock should be used through a concrete dam. This, however, can be understood when it is realised that large concrete dams are not homogeneous structures, as they are poured in separate blocks 20 ft. to 50 ft. square, with contraction joints between blocks, which are grouted tight after the cooling and setting of the concrete mass. The steel shell acts as a watertight liner through the dam, bridging over any joints left in the concrete or any cracks which may develop after construction. If it were feasible to pour dams in one solid mass and possible to produce watertight concrete and maintain it free from cracks when subjected to internal pressure and varying temperatures, the steel lining could be dispensed with.

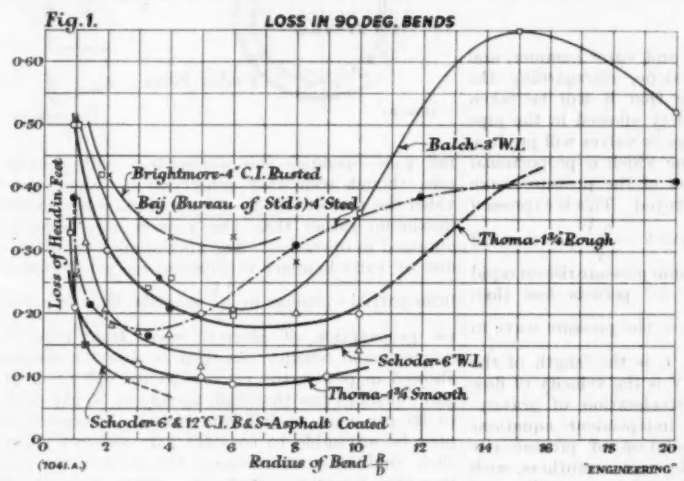
Penstocks may be designed on the basis of individual lines for each turbine or they may be combined into so-called headers, serving two or more power units with individual branches from the header to the turbines. Which scheme should be followed in a particular installation is a matter requiring careful consideration, the advantages and disadvantages of each being weighed. There is no doubt that having an individual penstock for each turbine has many advantages over the header system. Such installations are more flexible for operation and maintenance, turbine regulation is simplified, and complicated and costly branch connections and excessive diameters may be avoided. The header system, serving two or more branch lines, however, may have economic advantages over the individual penstock as far as losses in head and maintenance costs are concerned. This was found to be the case with the Boulder Dam penstocks, where the 30-ft. diameter header system with four 13-ft. branch penstocks was adopted for each tunnel,* because computations of head losses and maintenance costs showed a decided advantage for the one-header system as compared with the two-header system or the four individual lines for each tunnel. The head losses and maintenance costs were evaluated for each scheme and added to the construction costs submitted by tender. The combined costs showed the ultimate economy of each system. No rigid rules can be laid down relative to the most economical scheme for any and all cases; every installation must be analysed by itself, as the penstock problem cannot be treated separately, but must be correlated to the general plan of the dam, tunnels, and power house.

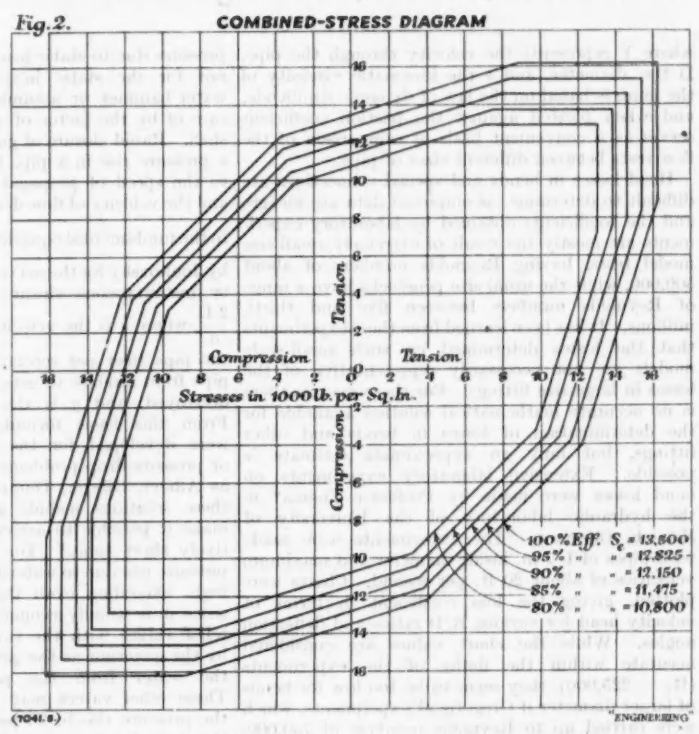
After establishing the profile and alignment of the penstock from the general plan adopted for the dam and power plant, an analysis should be made to determine the most economical diameter to be used. The penstock should be designed to deliver power water from the forebay or reservoir to the turbines at the most economical velocity. The diameter which will show the lowest total annual cost, including the value of power lost in friction and other hydraulic factors, depreciation, interest on the investment, taxes, operation and maintenance costs, will be the most economical to use. There are several methods available to determine the most economical penstock diameter; one of the most popular methods consists of plotting the total annual cost per foot of pipe as ordinates, and the length of the pipe in feet as abscissæ. Such curves are plotted for several representative diameters and the lowest curve on the chart represents the most economical diameter. This problem can also be solved with the use of formulæ developed by various authors, the latest and perhaps the most consistent of which was published by Charles Voetsch and M. H. Fresen in the November, 1936, *Transactions of the American Society of Civil Engineers*.

Before a representative economic analysis can be made it is necessary to prepare some preliminary designs of the penstock so as to be able to determine its length, the various bends and special connections, also the hydraulic losses for various diameters and pipe fabrication methods, unless the loss coefficients are introduced directly into the equations, as is done in the above-mentioned paper. Penstocks may be designed with a uniform diameter throughout or the diameter may be reduced with increasing head towards the power house, the proper scheme depending in each case on the economy of the installation. For very high head plants and steep profiles, the reducing-diameter penstock may often be more economical, as the saving in pipe tonnage may more than offset the value of the power lost in pipe friction. For plants where the pipe profile is rather flat, the uniform-diameter penstock is usually more economical, as the cost of reducers or reducing bends between diameter changes will increase the construction cost of the penstock, although the tonnage may be decreased. The value of power being different in each case, and the unit cost of penstocks being subject to considerable variations, no general rule can be formulated, but each installation must be analysed by itself.

Head losses in pipe lines vary roughly as the square of the velocity, but are also influenced by the surface condition of the interior of the pipe shell, this factor being introduced into the equation as the loss coefficient or the coefficient of retardation. These coefficients are determined empirically on the basis of laboratory experiments or from flow tests made on actual pipe installations. For steel pipe lines, Scobey's formula $H_f = K_s \frac{V^{1.9}}{D^{1.1}}$ has come into general use in recent years, being one of the most practical of the various formulæ produced. This formula gives the head losses for 1,000 ft. of pipe, where H_f = head losses due to pipe friction; K_s = coefficient of retardation, V = velocity in ft. per second, and D = diameter of pipe in feet. The retardation coefficient K_s varies with the surface roughness of the pipe due to the fabrication of the joints, also due to the type or condition of the interior coating of the pipe. Riveted pipe has a higher loss coefficient than welded pipe, as has a rough interior pipe compared with a smoothly coated or lined pipe. Cement-lined pipe is supposed to retain its interior surface smoothness and flow coefficient; this is also claimed for pipe lined with bituminous enamel. There is some uncertainty regarding these linings, as most of them are of somewhat recent origin and have not been in service long enough to prove their value and the claims made by their sponsors. Good judgment is essential, therefore, in the selection of the most serviceable lining for a given job. The coefficients recommended for the various types of pipe joints are given in Technical Bulletin No. 150 of the Department of Agriculture, entitled "The Flow of Water in Riveted-Steel and Analogous Pipes," by Fred C. Scobey, and published in 1930.

The well-known Reynolds number, $R_n = \frac{V D}{\nu}$,

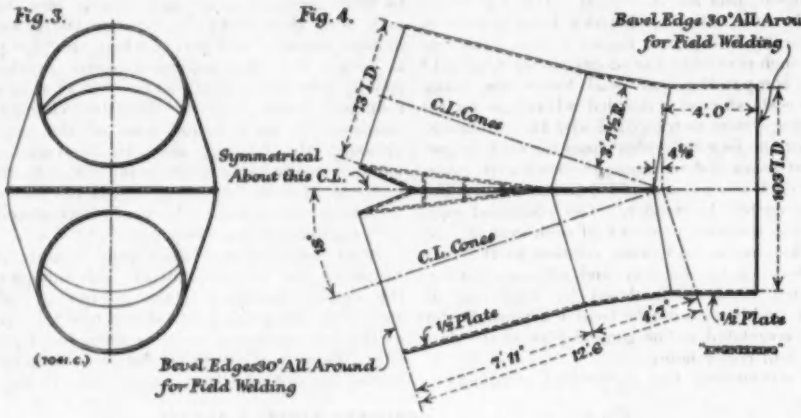


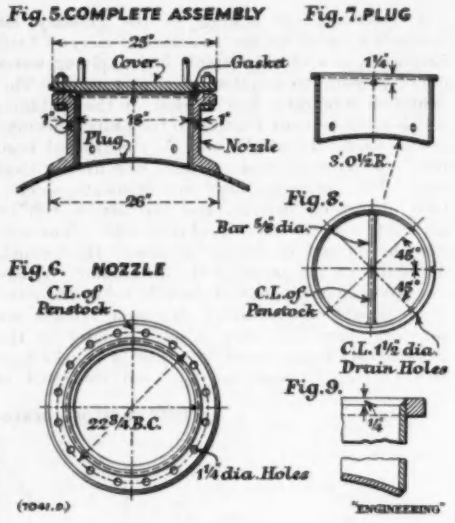


* United States Department of the Interior, Bureau of Reclamation, Denver, Col., U.S.A.

* See ENGINEERING, vol. 144, page 703 (1937).

PENSTOCKS FOR HYDRO-ELECTRIC POWER PLANTS.





where V represents the velocity through the pipe, D the diameter, and ν the kinematic viscosity of the fluid, is based on the law of dynamic similitude, and when plotted against the friction coefficient serves as a convenient basis of comparison of the flow tests between different sizes of pipe.

Head losses in bends and special connections are difficult to determine, as empirical data are meagre and the coefficients obtained by laboratory experiments are mostly the result of extremely small-size model tests, having Reynolds numbers of about 500,000, while the usual size penstocks have a range of Reynolds numbers between five and thirty millions. It has been learned from these experiments that the losses determined on such small-scale models are not necessarily representative of the losses in large-size fittings. For these reasons there is no accurate mathematical solution available for the determination of losses in bends and other fittings, but only an approximate estimate is possible. Extensive laboratory experiments on bend losses were made by Professor Thoma* in the hydraulic laboratory of the University of Münich, Germany. The experiments were made with pipes of 1·7 in. inside diameter and maximum velocities of about 20 ft. per second. Charts were plotted, giving the loss coefficient in terms of velocity head for various R/D ratios and deflection angles. While the chart values are considered accurate within the limits of the experiments ($R_n = 225{,}000$), they seem to be too low for bends of larger diameter if Gregorig's† experiments, which were carried up to Reynolds numbers of 750,000, are taken into consideration.

Recent tests‡ made in the National Hydraulic Laboratory by the Bureau of Standards, on 4-in. diameter 90-deg. steel bends for Reynolds numbers up to 350,000, also show a slight increase in bend loss with increasing Reynolds number, for all except two of the nine bends tested. The lowest loss is indicated for R/D (radius : diameter) ratios of about 3½. The bend-loss coefficients obtained in this test are considerably higher than the coefficients obtained, for similar R/D ratios and Reynolds numbers, by Thoma and Gregorig. Fig. 1, page 349, shows head losses for 90-deg. bends of varying roughness and for a Reynolds number of 225,000, as determined by the tests of various investigators. The majority of the curves show a favourable R/D ratio of 6. It is hoped that more tests will be made available on full-size installations in the near future to aid the hydraulic engineer in his work of computing flow capacities of conduits.

Penstocks should be designed for the combined pressure due to static head and water hammer, and not for the static head alone, disregarding the water hammer or assuming that it will be taken care of by the factor of safety allowed in the pipe shell. Rapid closure of gates or valves will produce a pressure rise in a pipe line which is proportional to the speed of propagation of the pressure wave and the velocity of flow destroyed. This is expressed in the fundamental equation of $h = \frac{a\,V}{g}$ put forward by Joukovsky for the maximum pressure rise on rapid or instantaneous closures, for periods less than $\frac{2\,L}{a}$, where a is the velocity of the pressure wave in the pipe (feet per second), L is the length of the pipe from forebay to gate, V is the velocity of flow destroyed, and g is the acceleration of gravity. From this basic formula independent equations were developed for the solution of pressure-rise or pressure-drop problems by various authors, such as Allievi, Gibson, Durand, Quick, etc. Some of these solutions include graphical methods which make it possible to arrive at an answer in a relatively short time.* For very long penstocks the pressure rise due to water hammer may become very high, exceeding even the static head. For such cases it is usually economical to provide auxiliary relief valves with the turbines, which are opened by the governor as the gates are closed and by-pass the water from the penstocks simultaneously. These relief valves may be proportioned to limit the pressure rise to 25 per cent. or 50 per cent. of the static head, or any other proportion considered most economical for the plant in question. In case of oncoming loads and the opening of the gates, a fall in pressure is registered. For long penstocks under medium and high heads it is often necessary to use surge tanks, which provide a reserve supply of water to meet sudden load demands during the period required for accelerating the flow in a long conduit leading to the tank. The surge tank greatly increases the period of oscillation of a surge wave and aids in turbine regulation. Such tanks or standpipes are usually located near the power house and are connected to the penstock by a short pipe section.

In determining the velocity of flow to be used in the water-hammer calculations, either the rated capacity of the turbines is taken and the water quantities computed therefrom, or the flow corresponding to the maximum reservoir level is taken, whichever scheme results in the highest total head. For lack of definite information relative to the law of gate movement, the time rate of change of the effective area of gate opening may be assumed a constant as based on a linear law of gate movement. While this is not strictly in accordance with operating experience, it is believed that for closures from full gate openings this assumption will produce safe, though somewhat conservative, values, provided the rate of change of area corresponds to the maximum rather than the average rate actually obtained in operation. The maximum pressure-rise due to water-hammer is obtained for gate closures from partial openings in $\frac{2\,L}{a}$ seconds (time required for propagation of pressure wave from gate to reservoir and return). As there is always a margin allowed in power, the rated capacity will occur at gate openings less than full, usually at 70 per cent. to 80 per cent. of full gate travel. Therefore, it may be advisable to consider gate closures under such conditions, and compute the pressure rise due to water hammer accordingly. There is no short analysis available for penstocks of varying diameter and shell thickness. For such cases it is customary, however, to simplify the problem by reducing the variable-diameter line to one of equivalent uniform diameter and to carry out the computations accordingly. Water-hammer computations for compound pipes are rather complex, as shown from a method used by R. E. Glover for the Boulder Dam penstocks.

After the pressure wave due to water hammer is determined from the computations, the line of pressure may be plotted on a profile of the penstock and the total head ascertained for every point along the line. The plate thickness can be computed with the usual thin-shell formula of $t = \frac{r\,p}{s\,e}$, where r is the radius of the pipe in inches, p is the internal pressure in lb. per square inch, s is the allowable working stress in lb. per square inch, and e is the longitudinal joint efficiency. The working stress should be proportional to the yield point values of the steel used in the construction of the penstock. It is very desirable to use a ductile steel of low carbon content (below 0·3 per cent.), which will produce a good weld capable of resisting shocks in the line and deformations without cracking. Firebox steels, A.S.T.M. designations A-89 and A-70, meet these requirements and are being used extensively for steel pipe lines. Such steels have minimum yield points of 27,000 lb. per square inch and minimum elongations of 25 per cent., which permits a gross "equivalent stress" equal to 13,500 lb. per square inch. This equivalent stress results from a combination of normal stresses called principal stresses, acting in two directions perpendicular to each other, in accordance with Becker's maximum shear and maximum strain theory.* Thus the longitudinal stresses (tension or compression) due to temperature changes in the pipe shell, and due to the pipe acting as a beam supporting its own

---

* *Transactions of the Münich Hydraulic Institute*, Bulletin No. 3, (Translation A.S.M.E., 1934), by D. Thoma and collaborators.

† Turbulente Strömungen in geraden und gekrümmten glatten Rohrleitungen bei hohen Reynoldsschen Zahlen; Bulletin No. 695 von der Eidgenoessischen Techn. Hochschule in Zürich, bei Romano Gregorig, 1933.

‡ "Pressure Losses for Fluid Flow in 90-deg. Bends," by K. Hilding Beij, *Journal of Research of the National Bureau of Standards*, vol. 21, No. 1, July, 1938.

* Symposium on Water-Hammer, by the A.S.M.E. Committee on Water-Hammer, June, 1933. "Comparison of Limitation of Various Water-Hammer Theories," by R. S. Quick, *Mechanical Engineering*, vol. 49, May, 1927. Reports of the Hydraulic Power Committee of the N.E.L.A., August, 1927.

* "On the Resistance of Ductile Materials to Combined Stresses in Two or Three Directions Perpendicular to One Another," by H. M. Westergaard, reprinted from the *Journal of the Franklin Institute*, May, 1920.

PENSTOCKS FOR HYDRO-ELECTRIC POWER PLANTS.

(*For Description, see Page* 349.)

Fig. 10.

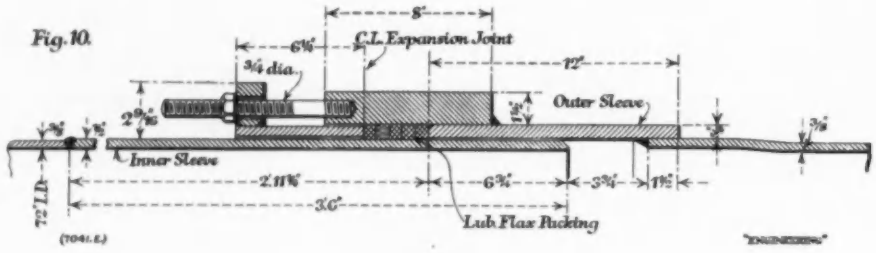


Fig. 11.

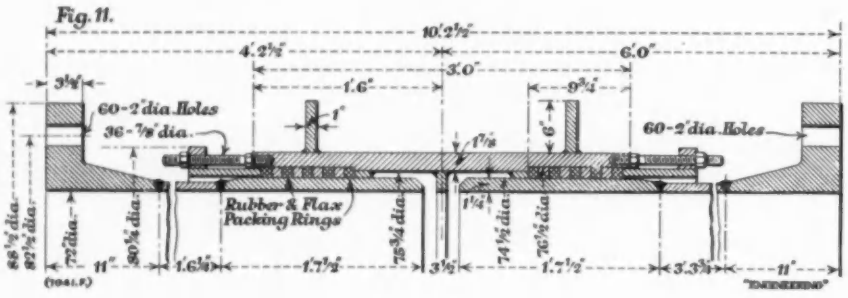


Fig. 16. WITH BUTT STRAP

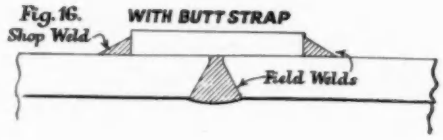


Fig. 17. WITH BELLED END

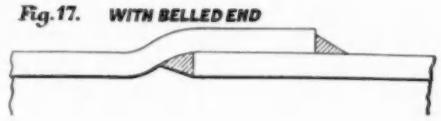


Fig. 18. BUTT WELDED

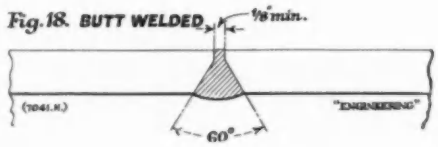


Fig. 12.

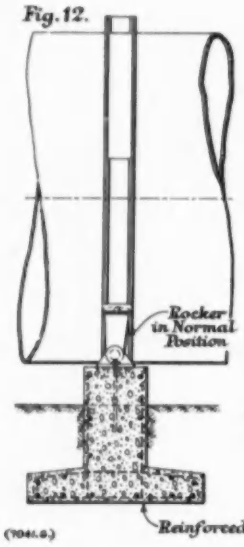


Fig. 13.

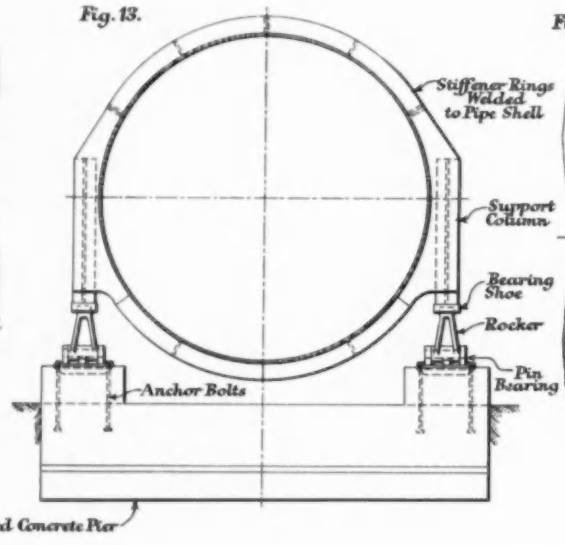


Fig. 14.

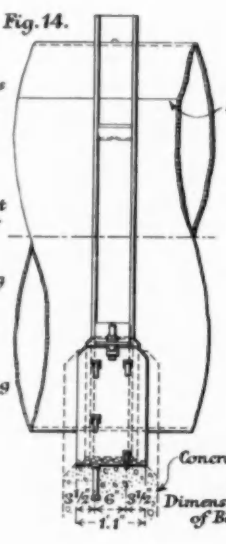


Fig. 15.

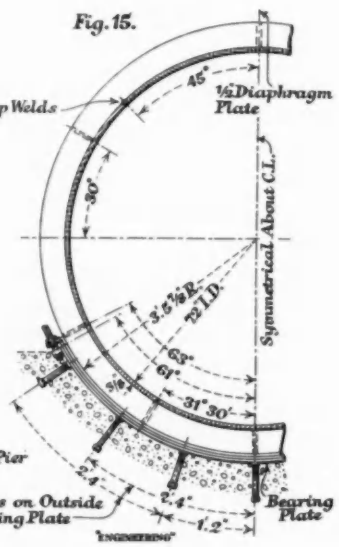


Fig. 19.

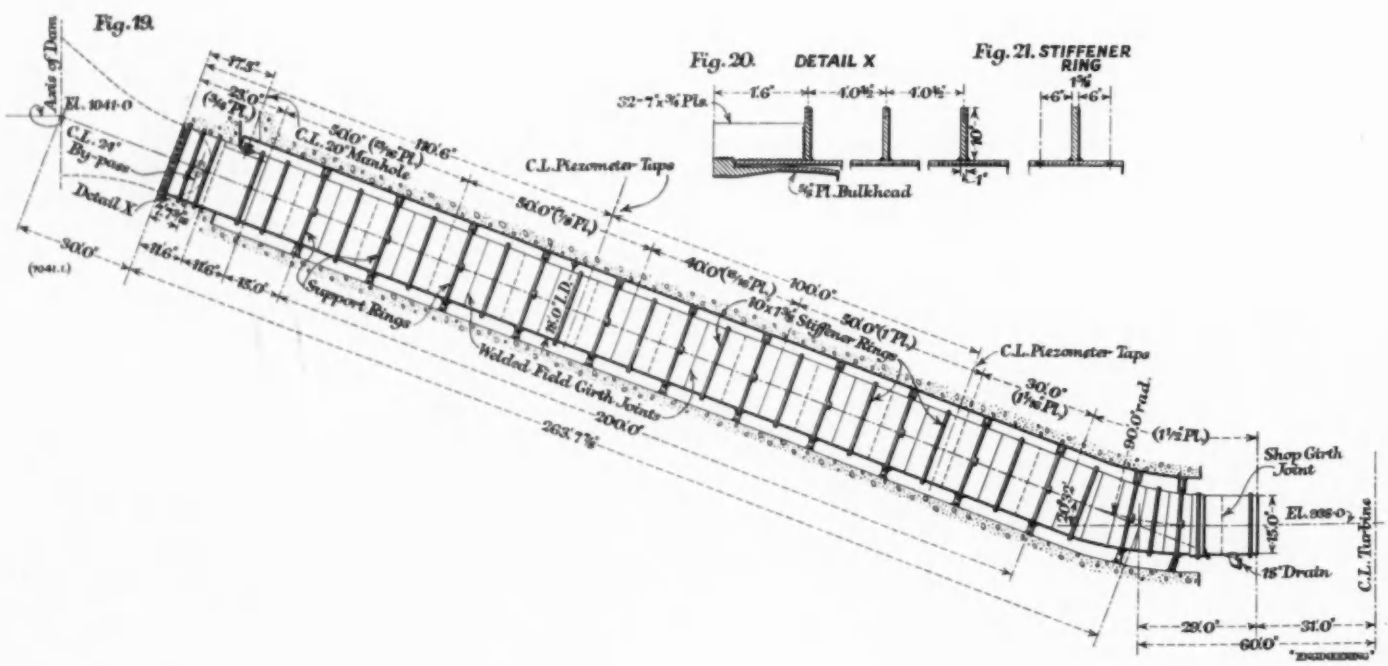


Fig. 20. DETAIL X

Fig. 21. STIFFENER RING

(*To face page* 351.)

weight and that of the water, will combine with the hoop stresses due to internal pressure acting perpendicularly to the pipe axis. Fig. 2, page 349, shows a combined-stress diagram for an equivalent stress of 13,500 lb. per square inch, with joint efficiencies of 80, 85, 90, 95, and 100 per cent., and corresponding "net equivalent stresses" as indicated in the five stress lines plotted on the chart. With the aid of this diagram permissible combinations for tensions in both directions or for tension, and compression may be determined quickly and accurately.

The "net equivalent stress" to be used will depend on the design and efficiency of the longitudinal joint. Since the introduction of the coated electrode, and consequent improvement in electric-arc welding, riveting has been replaced by welding to such an extent that practically all new pressure vessels and pressure pipes are of arc-welded construction. Considering the higher joint efficiencies and the improved flow capacity as compared with riveted pipe, the welded pipe is regarded as the cheaper of the two. Efficiencies allowed for properly welded joints vary from 80 per cent. to 95 per cent., depending on the type of welding and weld examination used, and on whether or not the welds will be stress-relieved. The 1938 edition of the A.P.I.-A.S.M.E. code for Unfired Pressure Vessels, sponsored by the American Petroleum Institute and the American Society of Mechanical Engineers, gives a basic joint efficiency of 80 per cent. for butt-welded joints and allows an increase to 85 per cent. with stress relieving, and to 90 per cent. for joints X-rayed but not stress-relieved. For joints which are both stress-relieved and X-rayed, the allowable efficiency is 95 per cent. These efficiencies are for firebox-grade steel with double butt-welded joints and single-welded butt joints with backing-up strips. For flange-grade steel, the allowable efficiencies are from 2 per cent. to 3 per cent. lower. As the stresses to be used depend on the joint efficiency, it is essential to determine the type of welding and weld examination to be employed before the plate thicknesses can be computed. For very low head penstocks the plate thickness is usually not a function of the head or the allowable stress, but is selected arbitrarily to satisfy the requirement of rigidity, fabrication standards, corrosion resistance, or other considerations. For some designs an extra metal thickness, from $\frac{1}{16}$ in. to $\frac{1}{8}$ in., is added to the calculated shell thickness to allow for corrosion and to increase the useful life of the pipe.

In many installations the penstocks are provided with flanges for bolting to gates or valves or to the turbine scroll case. These flanges should preferably be of forged or rolled stock; if they are of cast steel, this should be of the soft grade with a low carbon content suitable for welding. The flanges used are usually of the so-called welding-neck type, which facilitates welding to the pipe. As the welding tends to distort the flange, it is good practice to re-face the same after welding. To facilitate the alignment of adjoining flanges, slip-joints may be provided in the pipe adjacent to a gate valve or turbine inlet, or the welding of the nearest joint may be postponed until the flanges are aligned and bolted up. General rules for the proper design of the flanges are given in the A.P.I.-A.S.M.E. code. Typical rolled or forged steel flanges are shown at the ends of the expansion joint illustrated in Fig. 11, Plate XIX.

The rules for welding are covered in the A.S.M.E. and the A.P.I.-A.S.M.E. codes for unfired pressure vessels. A new code for large pressure pipes, such as penstocks, is now being prepared. Whatever code is followed, it must be borne in mind that the type of welding and weld examination to be used will depend on the importance of the job. No joint can be too good for an important penstock, as a safe penstock will protect life and property, and, therefore, it is desirable to have all welds X-rayed and defective welds chipped out and replaced with sound welds. Stress relieving of fabricated pipe sections is often resorted to where a first-class job is desired, and where a steel is used which is liable to air-hardening due to its higher carbon content. The object of stress relieving is to reduce the residual stresses caused by welding to an amount which is not considered hazardous. By slowly heating the pipe to 1,100 deg. or 1,200 deg. F., holding it at this temperature for at least one hour per inch of plate thickness, and cooling it slowly in the furnace to a temperature of 600 deg. F., and in still air below this point, all residual stresses of any consequence can be eliminated. While held at the stress-relieving temperature, some ductility is restored to the hardened zones and a readjustment in the structure takes place by the phenomenon of creep.

Penstocks have been welded, heretofore, with the multiple-pass welding system, in which the weld metal is deposited in individual layers of about $\frac{1}{8}$ in. thickness, each layer being cleaned and peened before succeeding layers are added, effecting thereby some measure of mechanical as well as thermal stress relief. This type of welding can be adapted to manual as well as to machine welding. In recent years, a single-pass high-current welding process, commonly called Unionmelt, has come into use, which is applicable to machine welding only. With this method the entire joint can be welded in one pass, using an automatic welding head for feeding a bare welding rod and controlling the electrical characteristics of the welding process. The flux feed travels ahead of the electrode and is fused into a slag or "melt" which covers the deposited weld metal and prevents its rapid cooling, effecting a certain amount of annealing thereby. A water-cooled copper backing-up bar is pressed against the under-side to secure thorough penetration. As an additional precaution, the weld at the bottom of the groove may be chipped out to sound metal, and back-welded by hand. Both longitudinal and circumferential welds can be made with the machine, which is held stationary while the pipe is moved on a trolley for the longitudinal welds and on a roller assembly for the circumferential welds. The single-pass welding process requires a close electrical and speed control for each plate thickness to produce good quality welds. This process is being used for the automatic welds of the Grand Coulee penstocks, for plates up to and including $1\frac{1}{16}$ in. in thickness. As the human element is a factor to be considered in welding procedure, the various codes require that all welders must pass a qualification test prescribed for that purpose. This test provides some protection against inexperienced or unreliable welders and should be employed on every important welding job.

Bends and other special connections, such as Y's, branch outlets, etc., should be designed so as to reduce turbulence and head losses in the penstock. Bends with radii of three to five diameters, and small deflection angles of from 5 deg. to 10 deg. between individual segments, will result in fairly efficient flow conditions. A typical reducing bend at the end of the Grand Coulee penstocks is shown in Fig. 19, Plate XIX, details being illustrated in Figs. 20 and 21. Figs. 3 and 4, opposite, show a welded-steel Y-branch design streamlined with back-grouted deflectors for more efficient flow. Branch outlets from headers should be slightly tapered or have rounded corners near the junction with the header. The openings left by the branch outlets, manholes, drains, and by-pass connections must be reinforced to compensate for the metal removed and to insure the structural adequacy of the opening. The cross-sectional area of the reinforcement required around the openings may be computed from formulæ given in the A.P.I.-A.S.M.E. code for fusion-welded vessels. Penstocks should be provided with manholes to permit admission to the inside of the pipe for inspection and maintenance purposes. Such manholes may be either circular or elliptical; for smaller penstocks they are usually located on the top of the pipe, and their size and spacing should be selected to provide convenient access for men, paint material, or tools to every part of the pipe line; 20-in. diameter manholes spaced from 200 ft. to 300 ft. apart have been found very serviceable. The manhole saddle should preferably be made of forged steel and the cover of cast iron or steel, depending on the head. The cover may be hinged to the saddle and should be streamlined to fit the interior diameter of the pipe. A typical manhole design is shown in Figs. 5 to 9, on the opposite page, having a plate-steel cover and a welded-steel plug to fill the opening for streamline effect.

Penstocks are often provided with piezometer connections and pipes for the purpose of making pressure-time water-flow determinations in connection with the efficiency tests of the turbines. Bronze or stainless-steel orifices are screwed into the shell at four points around the circumference and at two or more stations along the penstock, and pipe manifolds are connected to these. Individual lines are run from the manifolds to the measuring stations located in the power house. Penstocks located in the open or in tunnels are protected against movement by concrete anchors, which, in general, are located at the bends. Between anchors, the pipe tangents are provided with expansion joints which allow free temperature movements in the line. The anchors are designed to resist all forces due to temperature movements in the pipe, and the hydrostatic and dynamic forces acting at the bends. The resultant due to these forces will determine the volume of concrete required in the anchor, which will also depend on the nature of the underlying soil, its bearing capacity and sliding coefficient. A detailed discussion of anchor forces is given in the Penstock Report of the Hydraulic Power Committee of the Edison Electric Institute, published in 1936.

The expansion joints generally used are of the stuffing-box type, provided with three or more rings of long-fibre braided square flax packing, which is impregnated with a high-grade lubricant to render it plastic and watertight. The packing is compressed with a gland ring provided with closely spaced take-up bolts. The expansion joints for larger pipe are usually of welded-steel plate construction, and are sometimes machined to produce close sliding contact between the inner and outer sleeves. It is advisable to use heavier plates in the expansion-joint sleeves than for the adjoining pipe or to weld stiffener rings on the outside sleeves, to produce a more rigid expansion joint which will retain its shape and watertightness under all operating conditions. The expansion joints will also be found useful for the erection of the penstock, as they will permit adjustments in pipe lengths. It is advisable, therefore, to design the joint to take up not only the movement due to the maximum temperature range anticipated, but to allow also several inches extra clearance for discrepancies in pipe sections and change in pipe length due to welding. A typical expansion joint is shown in Fig. 10, Plate XIX, which was designed for a 72-in. pipe operating under a 75-ft. head. In plants where embedded penstocks run across construction joints provided between the dam and power-house concrete, a flexible joint is usually provided in the steel pipe so that the relative movement between the two concrete masses can take place without injury to the pipe shell. Such joints should be designed to permit both horizontal and vertical movements, which can be accomplished with a double-type expansion joint similar to the one shown in Fig. 11, Plate XIX.

Penstocks may be supported on concrete cradles or on concrete piers where the load is carried from stiffener to pier with a steel column. The cradle-type support usually covers the lower third of the circumference. Both cradle and pier-type supports require stiffeners to prevent undue deformations in the pipe shell. The supporting span may vary from 20 ft. to 100 ft. or more, depending on the cost of piers, the stiffeners, and shell reinforcement. Long spans require not only stiffeners, but heavier shells near the stiffeners to reduce the large bending stresses due to beam action. A pipe properly stiffened against deformation at the point of support provides a fairly rigid girder capable of carrying heavy loads for long spans without auxiliary supports or intermediate stiffeners. Extremely long spans are only economical, however, when the cost of supports is prohibitive, as in the case of crossing gulleys or rivers. The stiffeners required for supporting the weight of pipe and water must be designed to suit the particular type of support used. The column and pier type of support, as shown in Figs. 12 and 13, Plate XIX, is preferable, as it will not require as large stiffener rings as the usual 120-deg. saddle- or cradle-type support shown in Figs. 14 and 15. The column and pier type of support shown in Figs. 12 and 13 consists of a double stiffener ring which carries the load from

pipe to concrete pier by means of a short column or bracket which has an eccentric connection to the stiffener ring, thereby producing a resisting couple which counteracts the bending moment in the stiffener. Between the column and pier a hinged rocker set on a pin bearing is used, which permits the pipe to move freely along its axis with a minimum resistance and longitudinal stress in the shell. The pin bearing is grouted into the top of the pier after the penstock is erected and properly aligned. In setting the rocker bearings, care should be taken that the rockers will be in the vertical position when the mean temperature prevails in the penstock. In some installations rollers are used in place of rockers. Rocker or roller supports make it possible to locate expansion joints and anchors much farther apart than for supports where the temperature movement of the pipe is resisted by slide friction. The reason for this is that the longitudinal stresses in the pipe shell and the forces on the anchors are proportional to the length of the pipe to be moved by temperature changes, and to the frictional resistance at the supports. For steel on steel sliding surfaces the maximum friction coefficient is usually taken as 0·5, for rollers as 0·1, and for rockers as 0·15. The sliding friction, however, may be reduced to 0·25 or 0·3 with the use of two graphited-asbestos packing sheets between the two steel or steel and concrete surfaces of the supports. The pier type of support with two graphited packing sheets between steel column and support plate was used for the Boulder penstocks, while the roller and rocker-type supports were used for other important steel pipes constructed in recent years. The ring girders of the stiffener supports are computed from formulæ developed by the Bureau of Reclamation in line with the general theory discussed in Herman Schorer's paper on "The Design of Large Pipe Lines" (*A.S.C.E. Trans.*, vol. 98, page 101, 1935).

Penstocks made of a diameter which can be transported economically are usually shop-fabricated in 20-ft. to 30-ft. erection lengths, each of which may be X-rayed, stress-relieved, or pressure-tested in accordance with the particular requirements, before it is shipped to the site for installation. The plates, which are usually ordered to the proper size from the mill, are first edged or grooved to suit the particular type of welding used; they are then bent and rolled to the correct curvature and tack-welded into a cylinder composed of one or more sheets. The main welding operations are usually carried out on automatic welding machines, and the back-welding and repair welding of defects discovered by X-ray or visual inspection is done by hand. To prevent deformations in a thin-shell pipe, spiders are used during the fabrication until stiffeners are welded on the outside of the shell. After welding is completed the joints are radiographed with portable X-ray apparatus, this being done in strips about 12 in. to 20 in. in length, laid out and numbered consecutively on the welded seam. The defects disclosed by the radiograph are traced on to the seam and marked with crayon, after which they are chipped out and re-welded by hand. The repaired sections are again radiographed to prove the quality of the repair weld. After X-raying and repair welding, the sections may or may not be stress-relieved, depending on the quality of weld desired. It is a good practice to test every section of pipe with a hydrostatic pressure equal to 50 per cent. or 100 per cent. above the operating pressure, including water hammer, before they are released for installation. Such pressures should be maintained long enough to give the inspector ample opportunity to inspect every seam and portion of the pipe section for leakage. Before the pipe sections are ready for shipment, they may be shot-blasted or sand-blasted to bright metal and coated with a suitable primer.

The shop-fabricated pipe sections, which are properly fitted to each other prior to shipment, are erected to line and grade in the field and welded together to form the penstock. The field girth joint used between sections may be of the plain butt-welded type or the pipes may be provided with outside butt straps or bell ends, which will facilitate the assembly and aligning of pipe sections. The plain butt-welded joint is gaining in favour among engineers, as it transmits all stresses directly between sections without eccentricity, as in the case of the belled or butt-strap joint. The butt weld will also be accessible from both sides of the pipe and can be double-welded, assuring thorough fusion throughout the joint. Typical field girth joints are shown in Figs. 16, 17 and 18, Plate XIX. All shop and field operations should be controlled by a qualified inspector representing the purchaser of the penstock, who should also adjudicate the qualifications of the welders and the quality of the welds. For very large diameter penstocks which cannot be transported easily, a field fabricating shop is usually erected near the dam or power plant, and the pipe sections fabricated there, as was the case at Boulder Dam, and which is being done at present for Grand Coulee Dam. In the former case, all operations were performed in the field fabricating plant, while in the latter case the edging and rolling for the 18-ft. diameter penstocks (which are made from two halves) were carried out in the home plant of the contractor and the remainder of the fabrication is being completed in the field shop.

During transport of the pipe sections they should be blocked and stayed properly to prevent undue deformations in the shell. Proper handling equipment is necessary to place the pipe sections and perform all other field work necessary during installation. On important work it is desirable to radiograph all field welds, which are limited as a rule to the girth joints. After installation the penstocks are usually re-primed and painted either with coal-tar enamel or some other coating on the inside and with red lead and aluminium paint, or as desired, on the outside. It is advisable to subject the completed penstock to a hydrostatic pressure test to prove the adequacy of all field welding and installation work. Such tests are usually carried out at an excess pressure of at least 50 per cent. over the operating pressure, including water hammer. Considering that an unsafe penstock is a constant menace to life and property, every effort should be made to attain the highest perfection of design, fabrication, and construction. Figs. 19, 20 and 21, Plate XIX, show one of the 18 penstocks fabricated for Grand Coulee Dam. These penstocks are 18 ft. in diameter and are being installed in 24-ft. octagon-shaped tunnels provided in the dam. The space between pipe and tunnel will be backfilled with reinforced concrete. The penstocks are provided with hemispherical bulkheads at the upstream ends to prevent reservoir water from entering them during the work of erection and before the future units are installed. The lower end is reduced to 15-ft. diameter and will be connected to the turbine scroll case with a double-acting expansion joint similar to that shown in Fig. 11, Plate XIX, to allow for movement in the concrete construction joint between the dam and the power plant.

In conclusion, it will be of interest to describe briefly the operations involved in transporting the penstock sections from the fabricating plant to the Right-Hand Power House at the dam, as illustrated in Figs. 22 to 25, on Plate XX. For this purpose, a section was mounted on a specially-constructed trailer which was drawn by a powerful tractor truck. A second tractor truck was attached to the rear end of the trailer to give an additional braking effect on down grades. Fig. 22 shows the three vehicles, with a penstock section in position on the trailer, crossing what was formerly a railway bridge over the Columbia River, downstream of the dam. The latter can be seen in the background of Fig. 23, which shows the vehicles approaching the power station by a road along the river bank; in this position the rear truck is acting as a brake to hold back the load. Fig. 24 shows the tractor truck and trailer, run on to the flat-topped barge which was used to transfer the sections to the power station. On reaching the latter, the sections were lifted into the penstock tunnel by means of a derrick barge, this operation being illustrated by the photograph reproduced in Fig. 25. When placed in the tunnel, the sections were moved into place by a cable hoist. The space between the penstock and the tunnel walls will be filled in with reinforced concrete, as previously mentioned, the steel reinforcement for this purpose being carried on the penstock sections.

SOME EFFECTS OF SHORT-CIRCUITS ON THREE-PHASE TRANSMISSION LINES.

By T. F. Wall, D.Sc.

Among the more formidable sources of danger for the stability and continuity of the electric supply of a national grid system, short-circuits on the transmission lines are of outstanding importance. When large supply systems are coupled together an exact knowledge of the cause and possible consequences of every kind of disturbance which can arise, including those which are of only remote probability, is of the utmost technical and economic importance. If the insulation of one line fails and if the star point is earthed, the result will be a short-circuit of one phase. This will immediately raise the potential to earth of the other two phases so that there is every probability that all three phases will quickly become short-circuited to earth. A short-circuit must be cleared immediately on account of its disastrous possibilities for the electrical machines, apparatus and installation generally. If, for example, a short-circuit on all three phases persists for any appreciable time, all the induction motors in the region of the affected section will come to a stand-still, thus causing wide-spread dislocation of the industrial operations for which they are in use. If, however, the section of the system in which the short-circuit occur can be immediately isolated, serious damage to the rest of the system may be avoided. If the short-circuit is not immediately cleared, the cables and lines may be dangerously overheated, while immense mechanical forces may be developed of sufficient strength to tear out the cables and transmission links from their supports and, apart from these destructive effects on the system itself, the interruption to the continuity of the supply may cause grave losses to the consumers as well as serious damage to the prestige of the supply undertakings generally.

In America recently,* extensive practical investigations have been carried out in connection with a scheme which operates as follows: When a failure occurs in a section of the system, that section is automatically cut out of circuit and after an interval of time corresponding to a few cycles of the supply voltage, the section is automatically switched in again. In many cases, the short-circuit will by that time have cleared itself. If, however, the fault still persists, the section is again immediately switched out of circuit and, after a small fraction of a second, is switched in again. If the fault has not then disappeared, a further rapid switching in and out of circuit is made and if it then becomes evident that the short-circuit cannot be eliminated in this way, the faulty section is isolated for investigation and repair. Theory and practice both show that under certain conditions the greater part of the most frequently occurring short-circuits can be controlled so that there is no serious fall of pressure which cannot be limited to a duration of a small fraction of a second. The main object of this procedure is to ensure that any appreciable fall of pressure due to a short-circuit shall be prevented and, obviously the method can only be applied if it functions at a higher speed than the normally installed protective relays.

Apart from the possibilities of direct damage to the system, there are many other important possibilities of indirect damage and disturbance due to a short-circuit on power-transmission lines. For example, telephone, telegraph, and other light-current circuits in the neighbourhood may be dangerously disturbed while if the insulation breaks down between a line and a pylon erected in a field where cattle may be grazing or people may be present, the consequent earth currents may give rise to such steep potential gradients at the surface of the ground that dangerous, or even fatal, shocks may result.

In a previous article† an investigation of the magnitude of the currents which may be developed when a short-circuit occurs on large interconnected

* See Engineering, vol. 148, page 593 (1939). See also pages 522 and 635 of the same volume.

† Engineering, vol. 145, pages 348, 466 and 555 (1938).

PENSTOCKS FOR HYDRO-ELECTRIC POWER PLANTS.

(*For Description, see Page* 349.)

FIG. 22. PENSTOCK SECTION CROSSING BRIDGE OVER COLUMBIA RIVER.

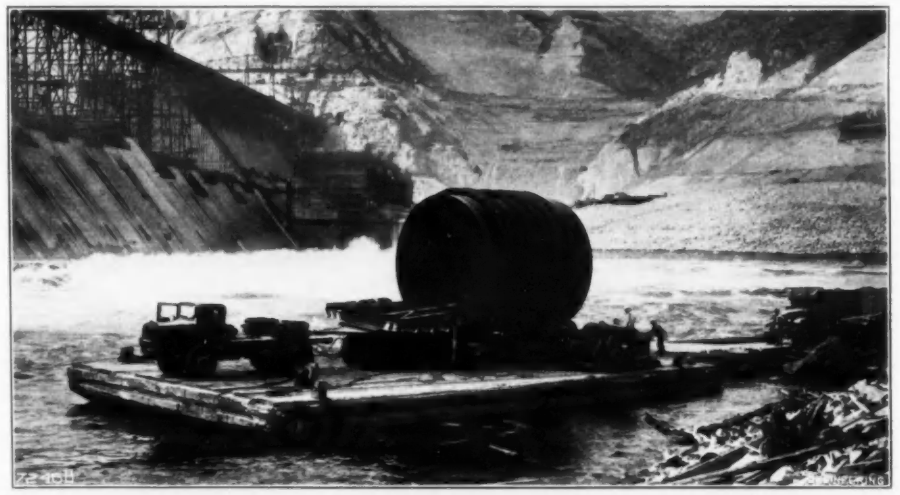


FIG. 24. TRANSPORTING PENSTOCK SECTION TO POWER STATION BY BARGE.

FIG. 23. PENSTOCK SECTION TRAVERSING ROAD ON RIVER BANK.

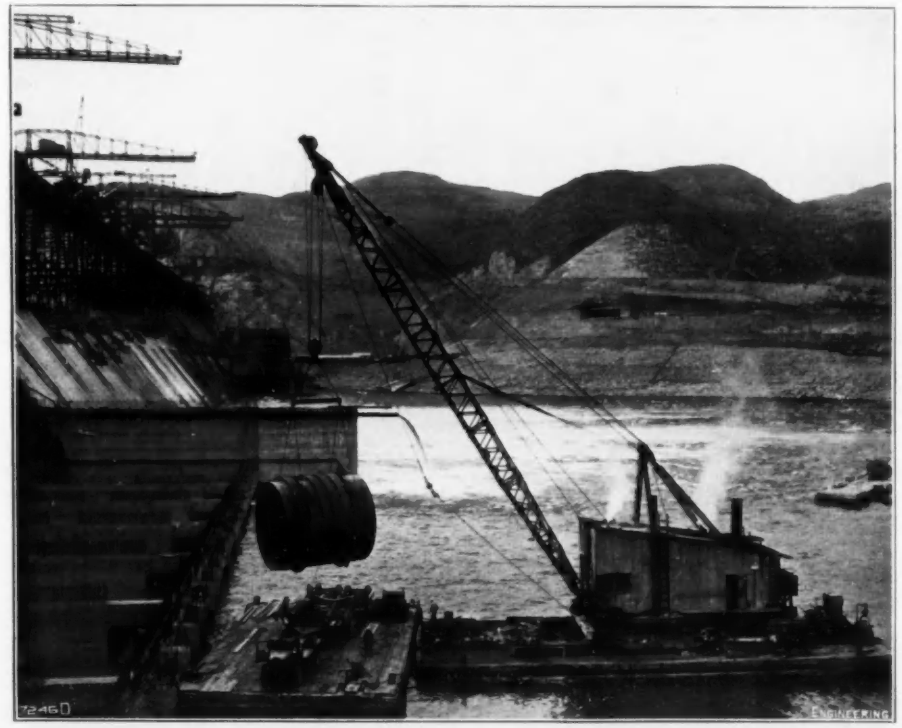
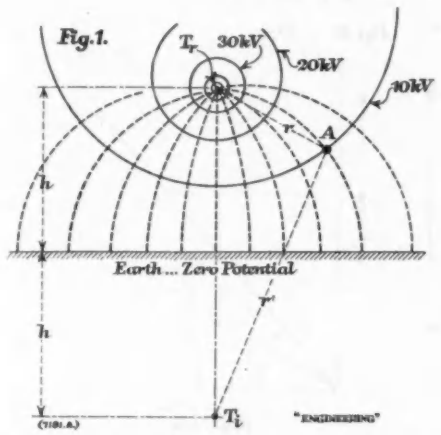
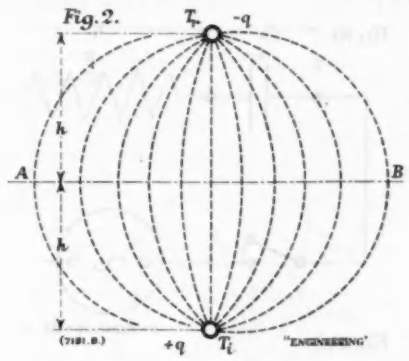


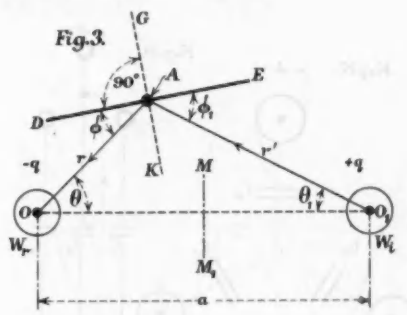
FIG. 25. LIFTING PENSTOCK SECTION INTO TUNNEL AT POWER STATION.

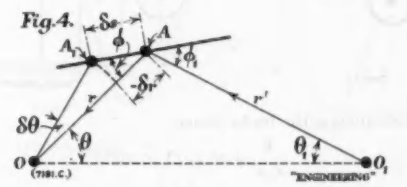
(*To face page* 352.)

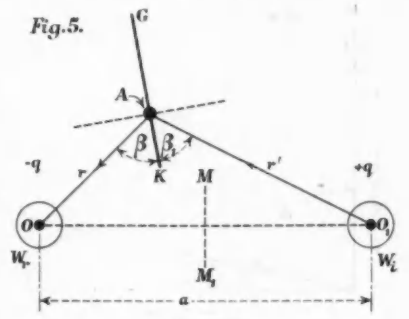
EFFECTS OF SHORT-CIRCUITS ON TRANSMISSION LINES.

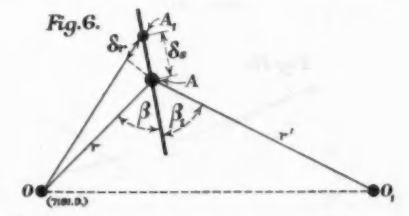


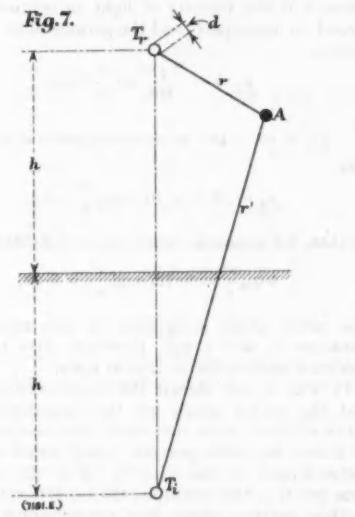












systems was given. In the first part of the present article some fundamental principles will be considered which greatly simplify the rather complicated problems involved in the investigation of short-circuits on three-phase transmission lines. In the second part, these principles will be applied to the consideration of some of the more important and representative types of such short-circuits met with in practice.

PART I.

1. *The Electrostatic Field Due to a Long Horizontal Wire Which is Electrically Charged.*—In Fig. 1 is shown a long horizontal wire T_r of diameter d, which is supported at a height h above the surface of the earth. The charge on the wire is assumed to be $-q$ units per centimetre length and the consequent electrostatic field which will be established between the wire and the earth's surface is defined by the tubes of force shown in Fig. 1 by the broken lines, the equipotential surfaces being indicated by the full lines. The shape of the tubes of force and of the equipotential surfaces for this case may easily be found by an application of the theory of electrical images. Thus, in Fig. 2 are shown two parallel wires T_r and T_i at a distance $2h$ cm. apart, and charged with $-q$ and $+q$ units per centimetre length, respectively. The plane midway between these two conductors is shown by the line A B. The electrostatic field between the conductor T_r and the plane A B in Fig. 2 will be identical with the field between the conductor T_r and the earth's surface in Fig. 1. The plane A B, indicated in Fig. 2, will be at zero potential and will thus correspond to the earth's surface in Fig. 1. The wire T_i in Fig. 2 is the electrical image of the wire T_r in the plane A B, and in Fig. 1 the electrical image of the wire T_r in the earth's surface is shown by T_i. The force at any point in the field shown in Fig. 1 can, therefore, be found as the resultant of the force due to the charged conductor T_r and the force due to its electrical image T_i in the earth's surface.

2. *Construction of the Tubes of Force.*—The equation which defines the shape of the lines of force may be found as follows: In Fig. 3, D A E represents the direction of the line of force through the point A and this direction is defined by the angles ϕ_1 and ϕ, respectively. The resultant force in the direction K A G, which is at right angles to D E, must therefore be zero, so that,

$$\frac{2q}{\epsilon r_1}\sin\phi_1 - \frac{2q}{\epsilon r}\sin\phi = 0 \quad . \quad . \quad (1)$$

But from Fig. 4 it is seen that

$$-\frac{r_1\,\delta\,\theta_1}{\delta s} = \sin\phi_1 : \frac{r\,\delta\,\theta}{\delta s} = \sin\phi$$

so that equation (1) may be written,

$$\frac{2q}{\epsilon}\frac{d\,\theta_1}{d\,s} + \frac{2q}{\epsilon}\frac{d\,\theta}{d\,s} = 0$$

that is,

$$\frac{d\,\theta_1}{d\,s} + \frac{d\,\theta}{d\,s} = 0 \quad . \quad . \quad . \quad (2)$$

Integrating equation (2) gives the relationship,

$$\theta_1 + \theta = k, \textit{ i.e.}, \text{ a constant} \quad . \quad . \quad (3)$$

It follows, therefore, that for all points on the line of force through A, the sum of the angles subtended at O and O_1 Fig. 3, must be a constant. This is the condition that the line of force is a circle through the axes O, O_1, and it will also be seen that the centre of this circle must lie on the line $M M_1$, which bisects the line O, O_1 at right angles. In this way the whole field of force due to the charged wires may be divided up into tubes of flux.

3. *Construction for the Equipotential Surfaces.*—The equation which defines an equipotential surface may be found as follows: In Fig. 5, G A K represents the direction of an equipotential surface through the point A and this direction is defined by the angles β and β_1, respectively. The characteristic of an equipotential surface is that the force in any direction along the surface is zero. It follows, therefore, that

$$\frac{2q}{\epsilon r_1}\cos\beta_1 - \frac{2q}{\epsilon r}\cos\beta = 0 \quad . \quad . \quad (4)$$

but reference to Fig. 6 shows that

$$\frac{\delta r_1}{\delta s} = \cos\beta_1 : \frac{\delta r}{\delta s} = \cos\beta$$

so that equation (4) may be re-written in the form

$$\frac{2q}{\epsilon r_1}\frac{d\,r_1}{d\,s} - \frac{2q}{\epsilon r}\frac{d\,r}{d\,s} = 0$$

or,

$$\frac{d\,r}{r_1} - \frac{d\,r}{r} = 0$$

that is,

$$\log_e\frac{r_1}{r} = k \text{ (a constant)},$$

so that,

$$r_1 = K_p\,r \quad . \quad . \quad . \quad (5)$$

where K_p is a constant.

Equation (5) is the equation of a circle of which the centre lies on the line O, O_1. By giving the constant K_p appropriate values, the circles for any equipotential surface may be obtained. The surface of zero potential will be given by the perpendicular line M, M_1, which bisects the line O, O_1 at right angles, this being, of course, a circle of infinite radius.

Example.—In Fig. 7 is shown a horizontal wire T_r of diameter d cm., electrically charged with $-q$ units per centimetre length and supported at a height h cm. above the surface of the earth. The electrical image of the wire in the earth's surface will then be charged with $+q$ units per centimetre length. The potential at any point A which is r cm. from the wire T_r, and r^1 cm. from the image T_i, may then be found as follows: The potential at A due to the wire T_r charged with $-q$ units per centimetre length, is the work which is done by the electrical forces in moving a unit positive charge from the point A to an infinite distance, that is,

$$-\int_r^\infty \frac{2q}{\epsilon}\frac{1}{r}\,d\,r = -\frac{2q}{\epsilon}\log_e\frac{\infty}{r}.$$

Similarly, the potential at A due to the charge of $+q$ units per centimetre length of the electrical image T_i is,

$$\int_{r^1}^\infty \frac{2q}{\epsilon}\frac{1}{r^1}\,d\,r^1 = \frac{2q}{\epsilon}\log_e\frac{\infty}{r^1}.$$

The resultant potential at A, therefore, is,

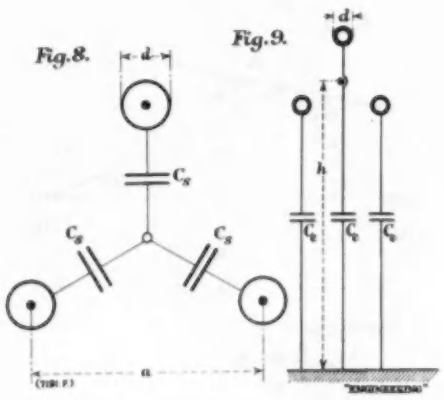
$$p_A = \frac{2q}{\epsilon}\left[\log_e\frac{\infty}{r^1} - \log_e\frac{\infty}{r}\right] = -\frac{2q}{\epsilon}\log_e\frac{r^1}{r}\text{ ergs} \quad . \quad . \quad (6)$$

when q is expressed in electrostatic units.

If q is expressed in electromagnetic units, the potential at A will be

$$p_A = -2\,q\,u^2\log_e\frac{r^1}{r}.$$

EFFECTS OF SHORT-CIRCUITS ON TRANSMISSION LINES.



electromagnetic units, since

$$\frac{1}{\epsilon\,\mu} = u^2 = (3 \times 10^{10})^2$$

where u is the velocity of light in centimetres per second, in open space, and the permeability is $\mu = 1$. Hence,

$$p_A = -\frac{2\,q\,u^2}{10^9}\log_e\frac{r^1}{r} \text{ volts.}$$

If

$$q = 0{\cdot}67 \times 10^{-9} \text{ in electromagnetic units,}$$

then

$$p_A = 27{\cdot}8 \times 10^3 \log_{10}\frac{r^1}{r} \text{ volts,}$$

so that, for example, when $p_A = -20{,}000$ volts,

$$\log_{10}\frac{r^1}{r} = 0{\cdot}72, \text{ and } \frac{r^1}{r} = 5{\cdot}23.$$

The circle which is defined by this ratio of the distances r', and r will therefore give the equi-potential surface for $-20{,}000$ volts.

In Fig. 1 are shown the equi-potential circles and the circles which are the boundaries of the tubes of force, such that each tube contains a flux of 20,000 in [volts per cm. : cm.^{2}] units per centimetre length of the wire T_r. For the numerical data given in this example, the electric force at the earth's surface along the tubes which are adjacent to the central line $T_r\ T_i$ is $f = \frac{dv}{dx} = 100$ volts per centimetre, while the breadth of the tube is 200 cm. at the earth's surface.

4. *The Capacitance and Inductance of Three-Phase Transmission Lines.*—In Fig. 8 are shown diagrammatically the three symmetrically-arranged lines of an overhead transmission system. The star capacitance in this case will be given by the expression

$$c_s = \frac{1}{2\log_e\frac{2a}{d}} \text{ electrostatic units per centimetre length of line per phase,}$$

$$= \frac{1}{9 \times 10^{11} \times 2\log_e\frac{2a}{d}} \text{ farad per centimetre per phase.}$$

The inductance will be given by the expression

$$l_s = \frac{2\log_e\frac{2a}{d}}{10^9} \text{ henry per centimetre length of the line per phase.}$$

It follows, therefore, that,

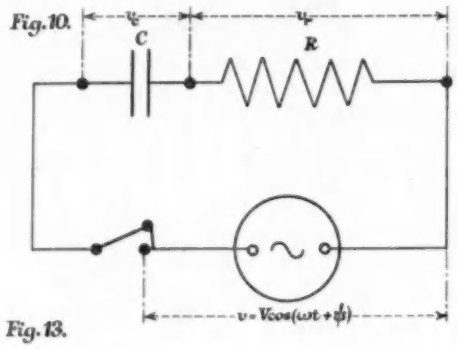
$$l_s \cdot c_s = \frac{1}{(3 \times 10^{10})^2} = \frac{1}{u^2}$$

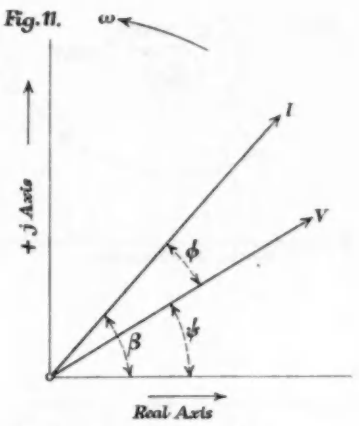
where u is the velocity of light in centimetres per second.

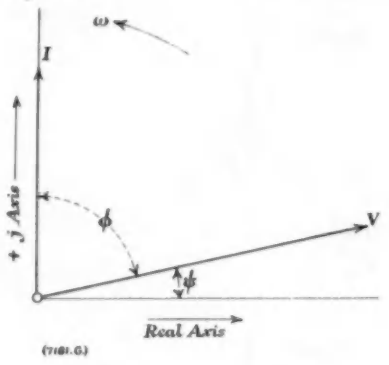
A more practically convenient form of expressing these results is as follows:
(l_s in millihenrys per km.) (c_s in microfarads per km.) $= 0{\cdot}0111$.

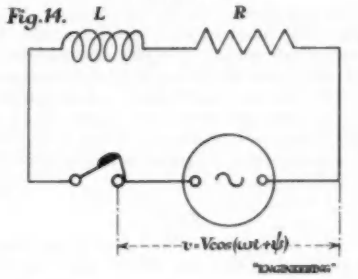
Example.—If the lines are 2 m. apart and if the diameter of each line is 1 cm., then

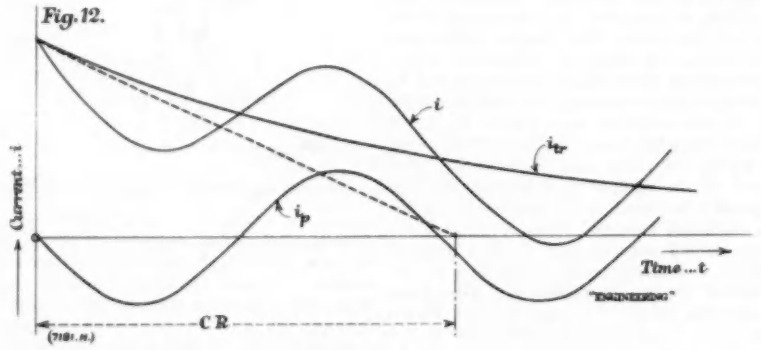
$$\log_e\frac{2a}{d} = 2{\cdot}3\log_{10}400 = 2{\cdot}3 \times 2{\cdot}6 = 6{\cdot}0,$$











so that the star capacitance per phase will be,

$$c_s = \frac{10^6 \times 10^5}{9 \times 10^{11} \times 2\log_e\frac{2a}{d}} = 0{\cdot}0093\ \mu\text{F per km.}$$

and the inductance per phase will be

$$l_s = \frac{2\log_e\frac{2a}{d}}{10^9} \text{ henry per cm.}$$

$$= 0{\cdot}2\log_e\frac{2a}{d} \text{ millihenrys per km.}$$

In Fig. 9, the three-phase lines are shown at an average height h above the earth's surface. The capacitance of each line to earth will be given by the expression,

$$c_e = \frac{10^6 \times 10^5}{9 \times 10^{11} \times 2\log_e\frac{4h}{d}} = \frac{1}{10\log_e\frac{4h}{d}}\ \mu\text{F per km.}$$

and the inductance of each line to earth will be,

$$l_e = \frac{2\log_e\frac{4h}{d}}{10^9} \text{ henry per cm.} = 0{\cdot}2\log_e\frac{4h}{d} \text{ millihenry per km.}$$

Example.—If the lines are 2 m. apart and the diameter of each line is 1 cm., and if the average height of each line above the surface of the earth is 9 m., then

$$\log_e\frac{4h}{d} = 2{\cdot}3\log_{10}3{,}600 = 2{\cdot}3 \times 3{\cdot}56 = 8{\cdot}2,$$

so that,

$$c_e = \frac{1}{18 \times 8{\cdot}2} = 0{\cdot}0068\ \mu\text{F. per km.}$$

and

$$l_e = 0{\cdot}2 \times 8{\cdot}2 = 1{\cdot}64 \text{ millihenrys per km.}$$

5. *Some Transient Phenomena.*—The following investigation of certain transient phenomena in capacitance and inductive circuits respectively have an important bearing on the operation of the Petersen coil method of quenching the arc due to the breakdown of a line insulator, as considered in detail in Part II of this article.

Case 1.—In Fig. 10 is shown a circuit consisting of a capacitance of C farad and a resistance of R ohms in series. To the terminal of this circuit is applied the p.d.

$$v = \text{V}\cos(\omega t + \psi).$$

The current i which will flow will, in general, comprise a transient term i_{tr} as well as the permanent term i_p, so that at any moment t the total current in the circuit will be

$$i = i_{tr} + i_p \text{ amperes.} \quad . \quad . \quad (7)$$

The permanent current term is found by the well-known methods (see also Fig. 11), and may be expressed as

$$i_p = \text{I}\cos(\omega t + \beta) \text{ amperes.} \quad . \quad (8)$$

where

$$\begin{cases} \text{I} = \dfrac{\text{V}}{\sqrt{\text{R}^2 + \left(\dfrac{1}{\omega\,\text{C}}\right)^2}} \quad . \quad . \quad (9) \\ \tan(\beta - \psi) = \tan\phi = \dfrac{\dfrac{1}{\omega\,\text{C}}}{\text{R}}. \quad . \quad (10) \end{cases}$$

The p.d. across the capacitance due to this per-

EFFECTS OF SHORT-CIRCUITS ON TRANSMISSION LINES.

Fig. 15.

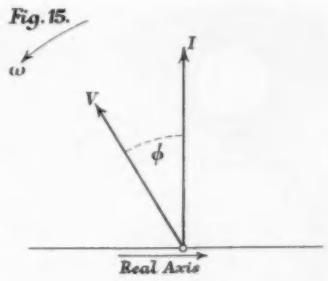


Fig. 16.

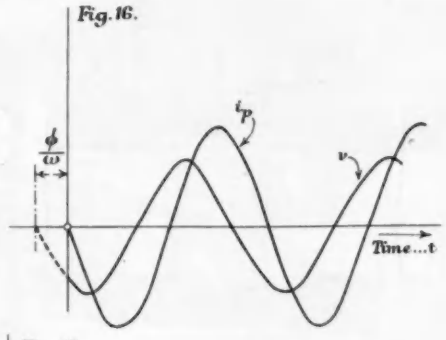


Fig. 17.

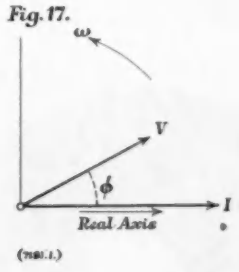


Fig. 18.

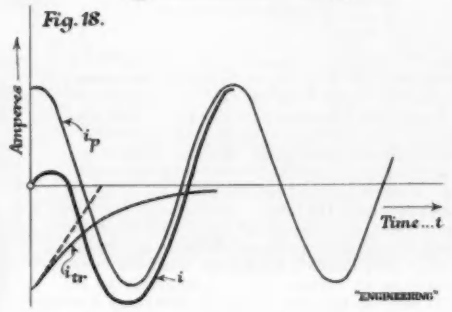
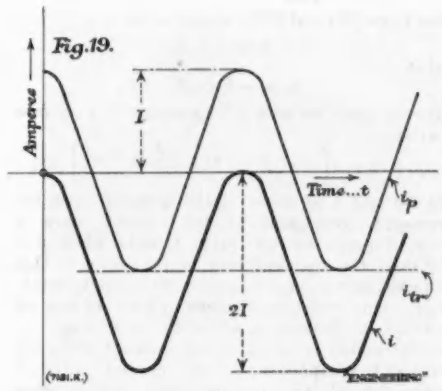


Fig. 19.



manent current term may be written

$$v_{cp} = \frac{q}{C} = \frac{1}{C}\int i_p \, d\,t \quad . \quad . \quad (11a)$$

that is,

$$i_p = C\,\frac{d}{d\,t}\,(v_{cp}) \text{ amperes} \quad . \quad . \quad (11b)$$

At the moment of closing the switch the p.d. across the capacitance is zero and the current i in the circuit is also zero, so that

$$i\,]_{t=o} = 0 = i_{tr} + i_p.$$

The transient term of current i_{tr} will give rise to a transient p.d. across the capacitance, such that the total p.d. v_c will be given by

$$v_c = v_{c\,tr} + v_{cp} \text{ volts} \quad . \quad . \quad (12)$$

and, at the moment of closing the switch,

$$v_c]_{t=o} = 0 = v_{c\,tr} + v_{c\,p} \text{ volts.} \quad . \quad (13)$$

The transient term of the capacitance p.d. will be of the form

$$v_{c\,tr} = K\,e^{-\frac{t}{CR}} \quad . \quad . \quad (14)$$

where the product C R is the "electrostatic time constant" of the circuit and K is a constant which is dependent upon the instantaneous value of the supply p.d. v at the moment of closing the switch, that is, for $t = o$.

The permanent term of the capacitance p.d. will be given by the equation (11*b*), viz. :—

$$i_p = C\,\frac{d}{d\,t}\,(v_{cp}),$$

or, making use of (7) (11*a*) and (8)

$$v_{cp} = \frac{I}{\omega C}\sin(\omega\,t + \beta) = V_{cp}\sin(\omega\,t + \beta). \quad (15)$$

Hence, from (11*b*), (12) and (13), for $t = 0$,

$$v_c]_{t=o} = o = K + \frac{I}{\omega C}\sin\beta,$$

or

$$K = -\frac{I}{\omega C}\sin\beta. \quad . \quad . \quad (16)$$

The p.d. v_c across the capacitance at any moment t therefore will be given by the expression

$$v_c = v_{cp} + v_{c\,tr} =$$

$$\frac{I}{\omega C}\left[\sin(\omega\,t + \beta) - \sin\beta e^{-\frac{t}{CR}}\right]. \quad . \quad (17)$$

or, since

$$V_{cp} = \frac{I}{\omega C} \quad . \quad . \quad . \quad (18)$$

$$v_c = V_{cp}\left[\sin(\omega\,t + \beta) - \sin\beta e^{-\frac{t}{CR}}\right] \quad . \quad (19)$$

The current in the circuit at any moment t will then be given by

$$i = C\,\frac{d}{d\,t}\,(v_c) =$$

$$C\,V_{cp}\left[\omega\cos(\omega\,t + \beta) + \frac{1}{C\,R}\sin\beta\,e^{-\frac{t}{CR}}\right]$$

that is

$$i = i_p + i_{tr} =$$

$$I\left[\cos(\omega\,t + \beta) + \frac{1}{\omega\,C\,R}\sin\beta\,e^{-\frac{t}{CR}}\right] \quad . \quad (20)$$

The relationship between the supply pressure V and the capacitance p.d. V_{cp} is obtained from (8) and (18), viz.,

$$V = V_{cp}\sqrt{1 + (\omega\,C\,R)^2} \quad . \quad . \quad (21)$$

It is to be observed that the greatest possible value of the transient current i_{tr} in (20) is obtained when $\beta = 90$ deg. (see Figs. 12 and 13). The current rush on closing the switch (*i.e.*, for $t = 0$), will then be

$$i\,]_{t=o} = i_{tr} = \frac{\frac{1}{\omega C}}{R}\,I \quad . \quad . \quad (22)$$

where I is the peak value of the permanent current i_p [see (7) and (8)].

Since in practice the ratio of the reactance $\frac{1}{\omega C}$ to the resistance R may be a very large quantity, the current rush when the switch is closed may reach an enormous value. For example, in the case of a cable of capacitance 10 μ F and resistance 1 ohm, supplied from a 50-cycle source, so that $\omega = 314$,

$$i_{tr}]_{max} = \frac{10^5}{314}\,I = 320\,I.$$

For the condition that $\beta = 90$ deg., that is, the condition that the permanent current wave is passing through a zero value at the moment of closing the switch, as shown in Figs. 12 and 13, the p.d. across the capacitance will be given by expression (19), viz.,

$$v_c = V_{cp}\left[\sin\left(\omega\,t + \frac{\pi}{2}\right) - e^{-\frac{t}{CR}}\right]$$

$$= V_{cp}\left[\cos\,\omega\,t - e^{-\frac{t}{CR}}\right]$$

or, substituting for V_{cp} in terms of V by means of (21),

$$v_c = \frac{V}{\sqrt{1 + (\omega\,C\,R)^2}}\left[\cos\,\omega\,t - e^{-\frac{t}{CR}}\right]$$

The maximum value of this expression for the p.d. across the capacitance will be reached when $t = \frac{\pi}{\omega}$, so that

$$v_c]_{max} = \frac{V}{\sqrt{1 + (\omega\,C\,R)^2}}\left[-1 - e^{-\frac{\pi}{\omega\,C\,R}}\right]$$

It is to be noted from Fig. 13 that when $\beta = 90$ deg., and for the condition that R is small in comparison with the reactance $\frac{1}{\omega C}$, the supply pressure will be practically at its peak value at the moment of closing the switch, that is, for $t = 0$. This result has significant practical consequences in connection with the operation of high-tension switchgear.

Case 2. Circuit containing inductance and resistance.—In Fig. 14 is shown an inductance of L henry in series with a resistance of R ohms and connected across the supply pressure,

$$v = V\cos(\omega\,t + \psi).$$

At any moment t seconds subsequent to the closing of the switch, the current i will be defined by the equation

$$L\,\frac{d\,i}{d\,t} + R\,i = V\cos(\omega\,t + \psi). \quad . \quad (23)$$

The solution of this equation consists of two parts, (*a*)

$$i_p = I\cos(\omega\,t + \beta) \quad . \quad . \quad (24)$$

where

$$I = \frac{V}{\sqrt{R^2 + (\omega\,L)^2}} \quad . \quad . \quad (25)$$

$$\tan(\psi - \beta) = \tan\phi = \frac{\omega\,L}{R}. \quad . \quad (26)$$

This expression defines the current which is eventually reached some considerable time after the closing of the switch; that is the "permanent" component of the current. Actually in practice this is usually established after a time corresponding to a few cycles of the supply pressure wave.

(*b*) A transient term,

$$i_{tr} = K\,e^{-\frac{R}{L}t} \quad . \quad . \quad (27)$$

where $\frac{L}{R}$ is the "electromagnetic time constant" of the circuit and K is a constant which depends upon the instantaneous value of the applied p.d. at the moment of closing the switch.

The actual current in the circuit at any moment t seconds subsequent to the closing of the switch will then be

$$i = i_p + i_{tr}$$

At the moment of closing the switch the current in the circuit will, of course, be zero, so that

$$i]_{t=0} = 0 = i_p + i_{tr}$$

hence from (24) and (27), when $t = 0$,

$$0 = \mathrm{I}\cos\beta + \mathrm{K}$$

so that

$$\mathrm{K} = -\mathrm{I}\cos\beta.$$

The complete solution of equation (22) may now be written

$$i = i_p + i_{tr} = \mathrm{I}\left[\cos(\omega t + \beta) - \cos\beta e^{-\frac{\mathrm{R}}{\mathrm{L}}t}\right] \quad (28)$$

If the switch is closed at the moment when the permanent component of the current wave is passing through its zero value, that is, when $\beta = \pm 90$ deg., the transient term will be zero, so that the permanent current becomes immediately established. This condition is shown in Figs. 15 and 16, page 355, for the case in which $\beta = +90$ deg.

If the switch is closed at the moment when the permanent component of the current wave is passing through its maximum value, that is, when $\beta = 0$ or π, the transient current term will have its maximum value. This condition is shown in Figs. 17 and 18, page 355, for the case in which $\beta = 0$. An interesting extreme example of this latter condition is that for which $\mathrm{R} = 0$. The transient term then becomes a steady direct-current term of magnitude I amperes, so that the resultant current i is then a unidirectional current wave of peak value equal to 2I, as shown in Fig. 19, page 355.

(*To be continued.*)

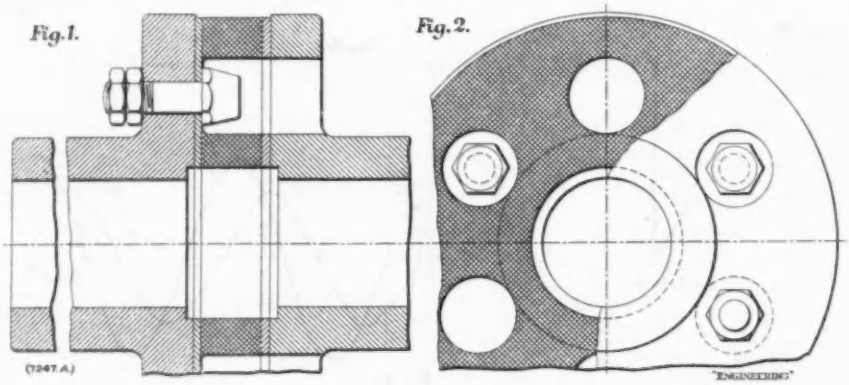
BONDED-RUBBER FLEXIBLE COUPLING.

A development of the torsional discs used in certain motor-car couplings and designed by Mr. Colin Macbeth, M.I.A.E., 67, Norwich Union-chambers, Congreve-street, Birmingham, 3, is the bonded-rubber flexible coupling shown in Figs. 1 to 3, on this page. The coupling, we understand, has been adopted as a standard by Messrs. General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. It is intended for general industrial application and the design comprises a range of sizes of which the smallest at present manufactured will transmit 3·33 h.p. at 100 r.p.m., while the largest will transmit 112 h.p. at the same rotational speed. The smallest size above referred to, viz., No. 3, of the range, is that shown in the illustrations and has been thoroughly tested in various ways, apart from having been in regular use for some 12 months. The torque is transmitted wholly through a rubber annulus, which is bolted to flanges keyed to the two shafts concerned. The bolts do not, however, pass through the rubber itself, since such an arrangement would naturally result in deleterious local stresses, but grip a pair of metal discs to which the rubber annulus is permanently bonded. The rubber annulus and metal discs are shown in the assembled condition in Fig. 3, but the sectional views of Figs. 1 and 2 are more informative.

The discs, which are of steel, ½-in. thick in the No. 3 coupling, are plated with brass alloy, which has an affinity for rubber, so that when the assembly of rubber and metal is subjected to a vulcanising process the two materials become chemically bonded to one another, with the result that the rubber, when subjected to very heavy shear load, will itself tear before the bonded joint is broken. In tests to destruction carried out by Messrs. General Electric Company, the rubber ruptured without failure of the bond under a 590 per cent. overload, a condition which it is extremely unlikely would ever occur in practice. Under normal running conditions, the load on the bonded faces varies from 20 lb. to 40 lb. per square inch according to the size of the coupling. The metal discs with the interposed rubber are clearly shown in Fig. 1. The rubber is of somewhat the same quality as is used for tyre treads; it is fairly soft and has a tensile strength of between 3,500 lb. and 4,000 lb. per square inch. The area of the bonded surface is not primarily determined by the load, nor, indeed, is it related to the shaft diameter, the shaft being often of larger diameter than is necessary for the power transmitted in order to provide stiffness, as, for example, in cases where the bearings are widely spaced. The flange diameter is proportionate to the shaft, and this more or less dictates the area of the bonded surface. The shaft diameter of the No. 3 coupling is 2⅛ in., and the flange diameter is 7⅛ in.

The discs are secured to the flanges by means of bolts arranged alternately, *i.e.*, one bolt couples one disc and flange, while the bolt next to it couples the other disc and flange. This arrangement will be clear from Fig. 1, while from Fig. 3 it will be realised that it involves alternate large holes, to admit the passing of the bolts, and small holes for the bolts themselves, in each flange, the holes through the rubber being all large enough to clear the bolt heads. These heads are of somewhat unusual shape, the base being formed with a shallow hexagon, so that the bolts can be prevented, by a box spanner, from twisting while the nuts are being screwed up. The major part of the head is, however, conical, the purpose of this formation being to prevent injury to the rubber should the coupling twist under heavy starting loads when the holes in the rubber take up an oblique position relatively to the flange. It may be mentioned that the couplings have been proved to be capable of being run for long periods under very heavy overloads when the shafts are $\frac{1}{16}$ in. out of parallel alignment, and have 1 deg. of angular misalignment. The bolt heads are obviously deeper than is necessary for the load imposed by the screwing up of the nuts. This is a precautionary measure only, the depth of the heads providing overlapping. Should the bond fail from any cause, the coupling would still function by power transmission between adjacent bolt heads and the portions of rubber between them. In an extreme case, where the rubber has disappeared completely, the bolt heads would make contact and the coupling would still drive. No case of a breakdown of the rubber of this nature has so far occurred, nor is such a breakdown anticipated, but by deepening the bolt heads even this remote contingency is provided for, and it would be impossible for a motor or other prime mover to be damaged by running away due to sudden release of the load on it. The No. 3 coupling has six bolts, ½ in. in diameter, the largest size of the range, viz., No. 14, for 112 h.p., having 10 bolts; 1 in. in diameter, the shafts for this coupling are 5½ in. in diameter and the flanges are 19⅝ in. in diameter overall. The bonded-rubber coupling is claimed to have a high capacity for tangential flexibility, this being normally some 4 deg. at full rated load.

BONDED-RUBBER FLEXIBLE COUPLING.



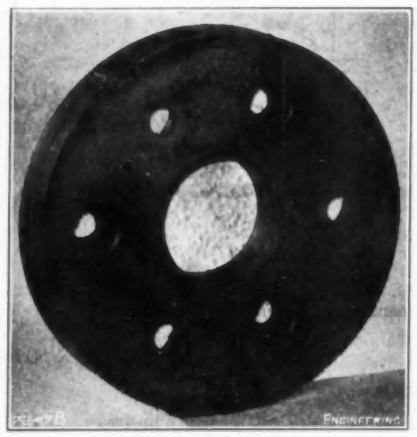


Fig. 3. Bonded-Rubber Disc.

VENTILATION OF MANHOLES.

For the past ten years the Federal Bureau of Mines in the United States have co-operated with the Boston Edison Company and the Boston Consolidated Gas Company in the detection and elimination of combustible and physiologically-harmful gases from manholes and in developing means to prevent the explosions which occur from this cause from time to time. These investigations, accounts of which have been published in our columns,* show that combustible gases from gas systems, underground tanks and petrol wastes can be located and the dangerous conditions remedied by continuous survey. Soil gases, which are present in manholes at times, are, however, more difficult to eliminate, because they have no fixed origin and because seasonal and barometric changes affect their production and flow. These gases are abnormally high in carbon dioxide and low in oxygen content, besides containing varying amounts of methane. They are, therefore, dangerous to men entering manholes.

Owing to the difficulty of constructing gas-tight manholes, the best method of eliminating these gases is by ventilation, and the Bureau of Mines, therefore, initiated a study of the various alternatives which would ensure not only the removal of these gases, but of unforeseen accumulations of combustible vapours. The results of this study are given in a Report, No. 3496, by Messrs. G. W. Jones, W. E. Miller and J. Campbell which has recently been published by the Bureau. These tests showed that, in general, the air changes taking place in a manhole roughly increase in proportion to the area of the openings in its cover. Though this factor is by far the most important, some changes are caused by the temperatures of the manhole and outside atmosphere, barometric changes, time of year and humidity. It was also found that the speed at which air passes across a ventilated manhole cover has a marked effect on the ventilation and that an increase from zero to 10 m.p.h. increased the ventilation by, on an average, over 50 per cent.

Since there is a limit to the number of openings that can be made in a manhole cover without appreciably weakening it, it is evident that where high rates of ventilation are desired other means of dissipating the deleterious gases must be used. Tests were, therefore, carried out to determine the efficiency of vertical ventilation ducts, both when used by themselves and in conjunction with ventilated covers. For this purpose, an experimental manhole measuring 60 in. by 83·5 in. by 76 in. deep from the cover to the bottom was used. One ventilation duct entered this manhole near the bottom and the other near the top. Both were 6 in. in diameter and their outlets were flush with the top of the concrete mat on the ground level. Before each test the cover was removed and the manhole purged with fresh air for several hours by means of a mechanical blower. The cover was then replaced and all the ventilation openings, except those required for the test, were closed with rubber stoppers. Natural gas was then passed into the manhole at the desired rate as indicated by a flow-meter, the actual quantities being measured by a wet meter. Usually, the tests were begun in the evening and continued all night so that the desired rate of flow could be accurately checked and the maximum concentration of gas reached in the manhole. The time required to reach this maximum concentration varied with the amount of ventilation and was usually from 1 hour to 8 hours. Samples of the atmosphere were taken at the top, middle and bottom of the manhole at four to eight-hour intervals, depending on the duration of the test. When tests lasted more than two days, the atmosphere was sampled three times a day. At the same time measurements were made of the temperature both inside the manhole and 2½ ft. above its cover, of the gas rate per hour, barometric pressure, average wind

* See Engineering, vol. 138, page 674 (1934), and vol. 147, page 326 (1939).

PHŒNIX SMALL-PART FINISHING MACHINE.

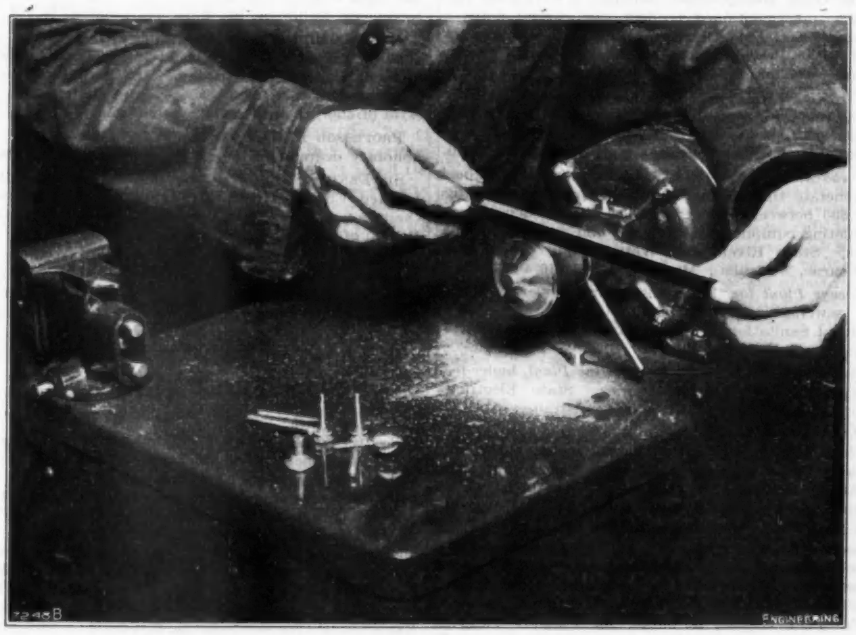


FIG. 1. FILE-FINISHING ARRANGEMENT.

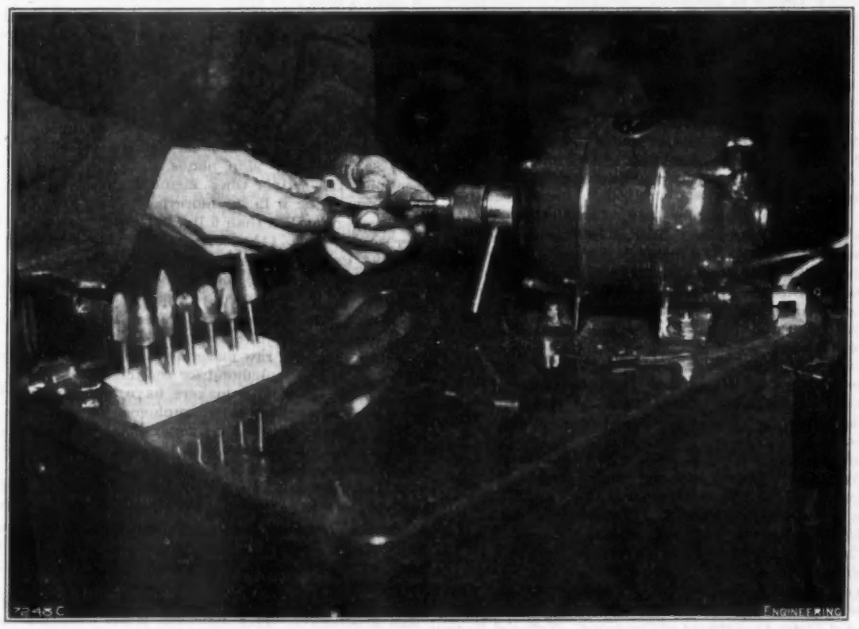


FIG. 2. BURRING ARRANGEMENT.

FIG. 3. PHŒNIX COMPACTA.

velocity, relative humidity, weather conditions and rainfall.

As a result of these tests it was found that the poorest ventilation was obtained when one duct, either the upper or lower, was used with no openings in the cover. The air changes were then fewer than four per day, showing that such an arrangement is practically useless for ventilation purposes. When the lower duct was used in combination with openings in the cover, the number of air changes rose from 2·3 per day with the lower duct only in use to 20 per day with the lower duct and six openings in the cover. With this combination, the ventilation was found to be roughly proportional to the number of openings in the cover. A cover with 48 openings used in conjunction with the lower duct gave about 60 times as much ventilation as was obtained when the duct was used alone. When the upper and lower ducts were used in conjunction with a solid non-ventilated cover, 92·1 air changes were obtained, thus showing the necessity and importance of having two ducts in every manhole—one near the top and the other near the bottom—in order to obtain good aeration. The use of two ducts in such positions created twenty-five times as many air changes as with one duct alone. Previous tests have shown that if the area of ventilation openings per 100 cub. ft. of manhole space is the same, then the number of air changes is about the same, irrespective of the size of the manhole, provided that other factors that might alter or disturb the ventilation are constant. Though the data given refer to a manhole with a capacity of 166·7 cub. ft., they may be applied to larger or smaller manholes by increasing or decreasing the size of the ducts and ventilation openings in proportion to the size of the manhole, since previous tests have shown that the air changes taking place in a given manhole are, roughly, proportionate to the area of ventilation openings per 100 cub. ft. of manhole space.

REMOVAL OF LEVEL CROSSINGS ON L.N.E.R.—The Ministry of Transport has authorised the Essex County Council to proceed with the removal of a number of level crossings on the Epping Branch of the London and North Eastern Railway. At the outbreak of hostilities a number of road-reconstruction works, necessitated by schemes for the removal of the crossings were postponed, and these works will now be put in hand.

PHŒNIX SMALL-PART FINISHING MACHINE.

THE machine shown in the accompanying illustrations, Figs. 1 to 3, and bearing the trade name Phœnix Compacta, has been recently added to the workshop equipment marketed by Messrs. E. H. Jones (Machine Tools), Limited, Edgware-road, The Hyde, London, N.W.9. The machine, as will be evident from the operations shown in Figs. 1 and 2, is not intended for heavy work, and, as shown in Fig. 3, is mounted on the top of a cabinet, which also carries a vice, so that the assembly constitutes a complete finishing bench for the small workshop. For larger factories it is claimed that the Compacta unit will prove of great use for such jobs as the correction of parts which may be slightly in excess of the specified size and which could not conveniently be returned to the machine on which they were made. A cardinal feature of the design is that the driving motor can be swivelled through an angle of 90 deg. in the horizontal plane towards the right, *i.e.*, so that the spindle lies farther over the table. It is shown so inclined in Fig. 2, in which a burring tool is being employed, an operation requiring a different form of support for the work than that used in the file-finishing operation shown in Fig. 1, in which the spindle axis is parallel to the side of the table. On the other hand, when a linishing disc is fitted to the spindle and a rest is used, as in Fig. 3, it is more convenient to work with the axis of the spindle parallel to the end of the table.

The motor is of ¼-h.p. and is generally run at a speed of about 1,750 r.p.m. It is usually supplied for alternating current, but a direct-current motor can be provided if preferred. The same latitude of choice applies to the voltage and other current characteristics. The motor spindle is finished with a taper nose from which the linishing disc can readily be removed by a quick-release device. Other tools or work are carried in a Jacob chuck; thus, a burring tool can be used, the work held for file finishing, drill-point grinding may be done on the periphery of a wheel, and suitable brushes or mops may be fitted for scratch brushing, ordinary polishing or French polishing. The cabinet is of sheet steel and special care has been taken in its design to avoid crevices which cannot be easily cleaned. The storage space in the cabinet measures 28½ in. by 16½ in. by 13½ in., and is divided into drawers and running shelving, as shown in Fig. 3. The table top is 19½ in. long by 15 in. wide, and 36 in. high from the floor. The unit is manufactured for Messrs. E. H. Jones by Messrs. Phœnix Telephone and Electric Works, Limited, Edgware-road, London, N.W.9.

ANNUALS AND REFERENCE BOOKS.

South and East African Year Book and Guide, 1940.—Of late, it has been repeatedly emphasised that the maintenance of our export trade is of vital importance in these present times and it is therefore essential that merchants and manufacturers should be able to obtain reliable information on those countries to which their goods may be exported. The importance of South Africa in this sphere may be gauged when it is realised that the value of the merchandise which imported from the British Empire—the bulk of which comes from the United Kingdom—exceeds the imports from all other countries of the world combined. The 1940 edition of *The South and East African Year Book and Guide*, containing a great deal of detailed information concerning most phases of life and activity in the Union of South Africa, as well as in East Africa and neighbouring territories, should prove of particular value to the industrial and business community. As has been the case with previous editions, the volume is divided into a number of sections, the two principal being devoted to general information and statistics regarding South Africa and East Africa. These sections contain chapters on such subjects as irrigation, farming, forests, live stock, mining and minerals, labour, population and resources, imports and exports, climate, Customs duties and languages. Other sections deal with South African and East African land routes, and the book concludes with a section which deals with the game of South and East Africa and with lists of works published on these two portions of the African Continent. Included in the volume is an excellent atlas by Messrs. John Bartholomew and Son, Limited, Edinburgh, comprising 64 pages of maps in colour. It is stated that all the maps are revised annually. There are also, in the text, 26 line plans of the principal towns and ports, seven of which have been specially drawn for the 1940 edition. The index, which occupies 57 pages, includes upwards of 4,000 place names. The price of the volume, which is edited annually by Mr. A. Gordon Brown, F.R.G.S., for the Union-Castle Mail Steamship Company, Limited, 3, Fenchurch-street, London, E.C.3, is 2*s.* 6*d.* net, or 3*s.* by post in the United Kingdom.

BRITISH STANDARD SPECIFICATIONS.

The following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 2*d.* including postage.

Seamless Brass Tubes.—Two specifications concerning seamless 70 : 30 brass tubes for general purposes have recently been issued. The first, No. 885-1940, relates to hard-drawn tubes having an ultimate tensile strength of between 25 tons and 35 tons per square inch. The second, No. 886-1940, concerns annealed tubes. Both specifications are embodied in one publication. They form part of a series of British Standards for non-ferrous metals and alloys and were drawn up as a result of a request from the Air Ministry and the Society of British Aircraft Constructors for a specification of more general applicability than those at present in use. In both specifications clauses relating to the chemical composition, manufacture, dimensions and testing of the tubes are laid down.

Standard Rules for Measurement of High Voltages.—A new specification dealing with the use of sphere-gaps for the measurement of high voltages has recently been issued. This supersedes and extends the rules presented in the previous edition of the specification, which was issued in April, 1929. The rules and calibration tables have been prepared by the British Electrical and Allied Industries Research Association after a study of available data and of work specially undertaken to clear up doubtful points. The tables given in the rules have received a large measure of international approval, and at a meeting of the Sphere-Gaps Sub-Committee of the International Electrotechnical Commission, held in Paris in July, 1939, it was agreed that those countries which proposed to issue national standards based on these tables were recommended to do so with the addition of a note to the effect that the figures in the tables might differ from the final I.E.C. values by an amount not exceeding 1·5 per cent. The tables are, nevertheless, considered by the Electrical Research Association to represent the most probable values of breakdown voltage for given sparking distances between the standard spheres. Line diagrams for sphere-gap voltage measurement are included, and these have been prepared to enable the calibrations and interpolations to be made rapidly and with an accuracy adequate for normal practice. The specification is designated No. 358-1939.

TENDERS.

We have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Wire and Wire Rope, comprising galvanised steel wire, strand and wire rope, and plain steel-wire flexible rope, of various sizes. State Electricity Commission of Victoria, Melbourne, Australia; April 30. (T. 17,337/40.)

Turbo-Alternator, 1,050 kW, horizontal, self-contained, to generate three-phase, 50-cycle current at a voltage of 6,600 between phases, together with condensing and circulating equipment, switchgear and protective apparatus. State Rivers and Water-Supply Commission, Melbourne, Australia; May 29. (T. 17,530/40.)

Sewage Plant for the extension and modernisation of the sewerage-purifying plant, Cordoba. Argentine National Sanitation Works Department, Buenos Aires; May 13. (T.Y. 17,636/40.)

Feed-Water Heating and Evaporating Plant, boiler-feed pumps, pipework and accessories. State Electricity Commission of Victoria, Melbourne, Australia; April 30. (T.Y. 17,684/40.)

Flow Meters, six, with 1-in. diameter outlet and suitable for use with fuel oil as used in compression-ignition motor vehicles, each meter to be fitted with a vertical 10-in. reading dial. General Stores Department, City of Durban, South Africa; April 19. (T. 17,732/40.)

Suction Dredger, with agitator, for isolated basins and Nubian pumping stations. Mechanical and Electrical Department, Ministry of Public Works, Cairo, Egypt; May 1. (T. 17,785/40.)

Heavy-Oil Engine, 35-b.h.p., for Chappri Pumping Station. Indian Stores Department; April 25. (T.Y. 17,871/40.)

Electric Lamps in quantity. The City Council, Johannesburg; May 15. (T.Y. 17,896/40.)

BOOKS RECEIVED.

The Directory of Shipowners, Shipbuilders and Marine Engineers, 1940. Compiled under the direction of the Editor of "The Shipbuilding and Shipping Record." London: The Directory Publishing Co., Ltd. [Price 20*s.* net.]

The Mining Year Book for 1940. Compiled by Walter E. Skinner. London: Walter E. Skinner, 15, Dowgate-hill, E.C.4; "Financial Times," 72, Coleman-street, E.C.2. [Price 20*s.* net.]

European Science. By Dr. H. S. Hatfield. Published for the Orthological Institute. Cambridge: The Basic English Publishing Co., 10, King's-parade. [Price 3*s.* 6*d.* net.]

New South Wales Legislative Assembly. Report of the Department of Works and Local Government for the Year Ended 30th June, 1938. Sydney, N.S.W.: Department of Works and Local Government. [Price 8*s.* 6*d.*]

Electrical Engineering Science. A Second-Year Course. By Drs. Arthur Morley and Edward Hughes. London: Longmans, Green and Co., Ltd. [Price 5*s.*]

The Calculation and Design of Electrical Apparatus. By Dr. W. Wilson. Second edition, revised. London: Chapman and Hall, Ltd. [Price 10*s.* 6*d.* net.]

Radioactivité et Transmutation des Atomes. By Dr. Théodore Kahan. Paris: Librairie Armand Colin, 103, Boulevard Saint-Michel. [Price 15 francs.]

United States Department of Commerce. National Bureau of Standards. Building Materials and Structures. Report BMS 35. *Stability of Sheathing Papers as Determined by Accelerated Aging.* By S. G. Weissberg, D. A. Jessup and C. G. Webber. Washington: Superintendent of Documents. [Price 10 cents.]

University of California. Publications in Engineering. The Design of Propeller Pumps and Fans. By M. P. O'Brien and R. G. Folsom. Berkeley, California, U.S.A.: University of California Press.

United States Bureau of Mines. Technical Paper No. 600. *Review of the Literature on the Construction, Testing and Operation of Laboratory Fractionating Columns.* By C. C. Ward. [Price 10 cents.] Technical Paper No. 602. *Inspection and Maintenance of Mine Hoisting Ropes.* By L. C. Ilsley and McHenry Mosier. [Price 5 cents.] Technical Paper No. 605. *Experiments on Strength of Small Pillars of Coal in the Pittsburgh Bed.* By H. P. Greenwald, H. C. Howarth and Irving Hartmann. [Price 5 cents.] Washington: Superintendent of Documents.

United States Bureau of Mines. Miners' Circular No. 39. *Central Mine Rescue Stations.* By J. J. Forbes and others. Washington: Superintendent of Documents. [Price 10 cents.]

United States National Bureau of Standards. Handbook H 35. *Safety Rules for Radio Installations.* Washington: Superintendent of Documents. [Price 10 cents.]

PERSONAL.

The address of the head office and southern branch of the Coal Utilisation Joint Council has been changed to General Buildings, 99, Aldwych, London, W.C.2.

Messrs. Livesey and Henderson, chartered civil engineers, Hardwick House, Whitchurch, Reading, Berks, have taken into partnership Mr. Andrew Brodie Henderson, A.M.Inst.C.E., as from March 31. The style of the firm will remain unchanged.

Professor F. G. Donnan, F.R.S., has received the honorary degree of D.Sc. of the University of Ireland.

Sir Ernest Simon, chairman of Messrs. Simon-Carves, Limited, Cheadle Heath, Stockport, has been appointed chairman of the Area Board for the North-Western Region of the Ministry of Supply.

Mr. W. Harpham and Mr. R. Reid-Adam, of the Department of Overseas Trade, have been appointed Commercial Secretaries, the former to H.M. Embassy at Cairo and the latter to H.M. Embassy at Washington.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scottish Steel Trade.—There has been no change in the state of the Scottish steel trade since the last report, and all plant is working at full capacity to keep pace with the heavy demand. The trade, on the whole, is responding well to the requirements of consumers and under the new rationing scheme, which came into operation this week, all users will receive a fair allotment of steel according to the importance of the work being done. While Government orders have preference, business of a general character is not being neglected. Export orders are also receiving favourable consideration, but the tonnage which can be spared is rather limited. The shipyards are exceedingly busy and are consuming a large quantity of steel. The raw material position has certainly improved, and the appeal of the Government for the collection of steel scrap has met with a ready response and a considerable tonnage has lately been gathered up. Not only has there been no falling-off in the demand for heavy steel, but a similar demand exists for light plates and sheets. Makers of these have heavy order books and are all fully occupied. Prices are unchanged and are as follows:—Boiler plates, 13*l.* 8*s.* per ton; ship plates, 12*l.* 10*s.* 6*d.* per ton; sections, 12*l.* 8*s.* per ton; medium plates, under $\frac{3}{16}$ in. thick, weighing 6 lb. or more per square foot, 14*l.* per ton; weighing less than 6 lb., but not less than 4·81 lb. per square foot, 14*l.* 10*s.* per ton; black-steel sheets, No. 24 gauge, in 4-ton lots, 17*l.* 10*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, in 4-ton lots, 20*l.* per ton, all delivered at Glasgow stations.

Malleable-Iron Trade.—The West of Scotland malleable-iron trade is quite active at the moment, and, with a better supply of raw materials, the conditions are more satisfactory. The demand for re-rolled steel bars is on a very large scale, and makers have sufficient work on hand to keep them fully employed for some time to come. Fortunately the deliveries of semies have recently amounted to a considerable tonnage. Current quotations are:—Crown bars, 12*l.* 17*s.* 6*d.* per ton; No. 3 bars, 12*l.* 10*s.* per ton; No. 4 bars, 12*l.* 15*s.* per ton; and re-rolled steel bars (tested), 14*l.* 3*s.*, all for home delivery.

Scottish Pig-Iron Trade.—The Scottish pig-iron makers are having to face a very strong demand from their regular customers and the current output is quickly absorbed. In these circumstances, all stocks have been used and buyers can only be supplied with the day-by-day production. This, however, is not sufficient for the local steel makers, and supplies are being brought in from other districts. To-day's market quotations are as follows:—Hematite, 6*l.* 7*s.* 6*d.* per ton, and basic iron, 5*l.* 4*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 5*l.* 15*s.* 6*d.* per ton, and No. 3, 5*l.* 12*s.* 6*d.* per ton, both on trucks at makers' yards.

Messrs. Crofts (Engineers), Limited.—During the last twenty or thirty years, a number of British engineering firms have produced catalogues which, by reason of the supplementary information contained, have almost acquired the status of standard text-books. One of the best known of these is that covering the power-transmission appliances held in stock by Messrs. Crofts (Engineers), Limited, Thornbury Works, Bradford, first published fourteen years ago. The seventh edition of this comprehensive reference book, containing 544 pages, fully maintains the standard of the previous editions, of which, it is stated, some 30,000 copies have been distributed. The catalogue portion occupies 462 pages, in which a considerable amount of technical information is incorporated; but, in addition, there is a valuable section containing tables and data, including extracts from those portions of the Factory Act, 1937, which directly affect users of power-transmitting machinery.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Only very limited new business could be negotiated on the Welsh steam-coal market last week, and shippers could take very little advantage of the business that was offering. Both home and foreign customers were displaying close attention and, with most collieries well stemmed over some months to come, the general tone was very firm. Mr. Dan E. James, in his inaugural address as president of the Cardiff Chamber of Commerce, said that South Wales had a duty to perform in seeing to it that Welsh coals were sent out to all the old markets. There must be a drive to increase exports and there should be great possibilities in this connection in view of the elimination of competition. To attain that end, however, it would be necessary to increase production. He prophesied that, as the shortage of coal grew abroad, the demand for British coals would increase and there was little doubt that this country, and perhaps even more so this district, could anticipate a very busy time in the months to come. There was again a keen request circulating for the duff coals. Supplies however, were almost entirely unobtainable for shipment over several months ahead and the tone was consequently very firm. Large and sized descriptions were not easy to secure for early shipment while smalls remained only very sparingly available. Cokes were in sustained request, but were scarce and firm. Patent fuel again displayed good activity.

The Iron and Steel Trade.—Brisk conditions ruled in the iron and steel and allied trades of South Wales and Monmouthshire last week. The demand for the various finished products was sustained and most producers were kept busy in executing orders already on their books.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Intense activity prevails in all sections of local industry. Orders are coming to hand in large numbers, while manufacturers are receiving more overseas inquiries. Sheffield Chamber of Commerce, in its annual report, states that its Trade Inquiries Department last year received the usual quota of queries from all parts of the world. While the large Sheffield steel and engineering firms continue to break output records, work in the research laboratories is not neglected. Lord Aberconway, chairman of Messrs. Thos. Firth and John Brown, Limited, told the shareholders: "The company has always regarded the adequate prosecution of scientific research in relation to its processes and products as a cardinal point. During the past year, important work in new fields of research has been made possible by the addition of the most modern forms of apparatus, and I am happy to say that in several directions valuable progress has been made." The demand for all types of steel has been maintained. Inquiries at consuming works show that larger supplies are available. High-efficiency steels are in strong request. Messrs. Thos. Firth and John Brown, Limited, report a notable increase in the sales of hard metal-cutting alloys. The increased output of their department, now not far short of one million pounds per annum, is attributable not only to a larger home demand, but also to the substitution of home-produced supplies for goods formerly purchased from abroad. The heavy engineering and machinery-making branches are operating at high pressure. Steelworks and ironworks machinery is in record demand, and extensions are taking place at many works, giving rise to a demand for structural steel, power plant, lathes, and similar machines.

South Yorkshire Coal Trade.—Larger tonnages of coal are available for disposal. Industrial concerns are taking heavier supplies, while electricity and gas-making undertakings are also placing orders more freely. Business in house coal is good, and there is a lively demand for coke. The export market is a little more active.

REGISTRATION OF ROAD MOTOR VEHICLES.—According to an announcement made by the Ministry of Transport, 9,090 mechanically-propelled road vehicles were registered for the first time during February, 1940, as compared with 33,907 in February, 1939.

SUSPENSION OF LICENCES FOR CERTAIN COMMODITIES.—The Board of Trade announces that, until further notice, no applications will be considered for licences authorising the importation of accumulators and parts, electrical-bell apparatus, bell domes and bell gongs, blast-furnace slag, optical lanterns, latches, hinges and locks, and wireless receivers, from foreign countries other than France. The announcement, however, does not apply to goods to be imported for re-export or for use in the export trade.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The production of many descriptions of iron and steel has been increased to the limit of the plant in operation, but the demand continues on an unprecedented scale. Manufacturers of most commodities have orders to execute that will keep them busily employed for some months.

Cleveland Iron Trade.—The pressure for the supply of foundry iron is not so intense as it was owing to slackness at the works making light castings, the demand for which has decreased owing to continued inactivity in the building trade. The make of the usual brands of Cleveland pig is still suspended and production of substitute foundry iron is intermittent and small, but deliveries of Midland products are maintained at a regular rate that readily covers requirements. Second hands are able to obtain only trifling parcels of local iron and their dealings in tonnage from elsewhere are not extensive, consumers buying mainly direct from the makers. The fixed prices of Cleveland pig are based on No. 3 quality at 111*s.* delivered within the Tees-side zone.

Hematite.—The large make of East Coast hematite is passing promptly into use. Makers' stocks have fallen to small dimensions and consequently business is confined to very narrow limits. Consuming plants owned by hematite producers are absorbing heavy and increasing tonnage, and customers dependent on the market for supplies are anxious to negotiate for larger tonnages to cover their needs over periods ahead. The actual consumption requirements continue to be steadily met and makers confidently hope to cover essential needs. Stabilised quotations are at the level of No. 1 grade of hematite at 127*s.* 6*d.*, delivered to North of England firms.

Basic Iron.—The price of basic iron remains nominally 104*s.* 6*d.* Makers have no tonnage for sale, their steel-making plant taking up the output as it becomes deliverable.

Foreign Ore.—Imports of foreign ore are regular and large and users have satisfactory stocks.

Blast-Furnace Coke.—Local consumers of Durham blast-furnace coke have little occasion to buy, having made extensive provision for their needs, and sellers are not offering parcels at all freely at the recognised market values, inclining to the belief that the position justifies rather higher figures. Market quotations are ruled by good medium qualities at 31*s.* 8*d.* at the ovens.

Manufactured Iron and Steel.—Supplies of semi-finished iron and steel are well maintained and are keeping the re-rolling mills fully employed. The make has been somewhat increased and the import of Continental semies continues to be regular and substantial. Manufactured-iron firms have large orders to carry out and finished-steel producers are operating their plants at full capacity. The new regulations for distribution are expected to remove some of the complaints regarding delays in supply.

Scrap.—The scarcity of some kinds of iron and steel scrap is becoming somewhat less acute.

THE MESSEL MEDAL.—The Society of Chemical Industry has awarded the Messel Medal for 1940 to Viscount Samuel, G.C.B., G.B.E.

CALENDAR.—Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, have sent us a monthly tear-off calendar dating from April, 1940, to March, 1941.

THE BRITISH CHEMICAL STANDARDS.—At the recent annual meeting of the Bureau of Analysed Samples, Limited, 3, Wilson-street, Middlesbrough, it was reported that two new British Chemical Standards, namely, an 88/10/2 gunmetal and a high-silicon, high-phosphorus cast iron had been issued during 1939, and that two new standards, namely, a 78 per cent. to 80 per cent. ferro-manganese and an 18/8 stainless steel, were being analysed previous to issue. The year ending November 30, 1939, it was pointed out, constituted a record for the sale of the standards, these amounting to 2,613*l.* in value, or 450*l.* more than in the previous twelve months. As a precautionary measure, shortly after the outbreak of war, a certain number of all the certificates of analyses and some of each of the finished standard samples, as well as some of the steel bars from which the standard drillings are obtained, were stored in a place of safety to ensure continuity of records and supplies in the event of the main supplies at Middlesbrough being damaged or destroyed. Interest in spectro-chemical methods of analysis for steel is growing, and the directors of the Bureau are giving some consideration to the advisability of preparing a series of suitable standard pieces.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF CHEMICAL ENGINEERS.—To-day, Hotel Victoria, Northumberland-avenue, W.C.2. 11 a.m., Eighteenth Annual Corporate Meeting. 11.45 a.m., Presidential Address: "Oil," by Mr. F. H. Rogers.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Meter and Instrument Section:* To-night, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. "Developments in Surge Recording by Means of the Klydonograph" (E.R.A. Report), by Mr. J. L. Candler. *North-Eastern Centre:* Monday, April 8, 6.15 p.m., The Newe House, Pilgrim-street, Newcastle-upon-Tyne. "The Limitation of Transformer Noise," by Messrs. B. G. Churcher and A. J. King. *Transmission Section:* Wednesday, April 10, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. (i) "The Development of a Pre-Stressed ('Toughened') Glass Insulator," by Mr. P. M. Hogg. (ii) "The Performance of Glass Insulators and Comparisons with Porcelain" (E.R.A. Report), to be presented by Mr. C. E. R. Bruce and Dr. S. Whitehead. *Institution:* Thursday, April 11, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. Ordinary Meeting. "The High-Rupturing-Capacity Cartridge Fuse, with Special Reference to Short Circuit Performance," by Mr. J. W. Gibson.

JUNIOR INSTITUTION OF ENGINEERS.—*Sheffield Section:* To-night, 7.30 p.m., The Metallurgical Club, West-street, Sheffield. Annual General Meeting. "Noise, Intelligible and Otherwise," by Mr. Donald Taylor. *Institution:* Friday, April 12, 6.30 p.m., 39, Victoria-street, Westminster, S.W.1. Ordinary Meeting. "Fluid Flow in Pipe Lines and Fittings," by Mr. S. J. Moore.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Lancashire Branch:* Saturday, April 6, 3 p.m., Engineers' Club, Manchester. "Pattern Making and Foundry Production," by Mr. C. Joynes.

INSTITUTION OF THE RUBBER INDUSTRY.—*London and District Section:* Monday, April 8, 7 p.m., Northumberland Rooms, Northumberland-avenue, W.C.2. Annual General Meeting. Symposium: "The Utilisation of Waste Rubber."

INSTITUTION OF AUTOMOBILE ENGINEERS.—*Birmingham Graduates' Branch:* Monday, April 8, 7.30 p.m., The James Watt Memorial Institute, Birmingham. Informal Discussion: "An Answer to the High Horse-Power Tax and Petrol Rationing." *Luton Centre:* Tuesday, April 9, 7.30 p.m., The George Hotel, Luton. "The Use of Gas as a Fuel for Motor Vehicles," by Dr. J. S. Clark.

ILLUMINATING ENGINEERING SOCIETY.—Tuesday, April 9, 6 p.m., The E.L.M.A. Lighting Service Bureau, 2, Savoy-hill, W.C.2. "The Photometric Properties of Luminescent Materials," by Dr. W. E. Harper, Miss Margaret B. Robinson and Mr. J. N. Bowtell.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, April 9, 6 p.m., 39, Elmbank-crescent, Glasgow, C.2. "Electrolytic Action on Steel in Sea Water," by Dr. J. H. Paterson.

INSTITUTION OF PRODUCTION ENGINEERS.—*Birmingham Graduate Centre:* Tuesday, April 9, 7 p.m., The James Watt Memorial Institute, Birmingham. Annual General Meeting. Chairman's Address by Mr. J. H. Bailey. *Leicester and District Section:* Thursday, April 11, 7.30 p.m., The College of Technology, Leicester. Annual General Meeting. Films: (i) "The Manufacture of Tool Steels and Small Tools." (ii) "The Manufacture of Heavy Forgings." *Yorkshire Section:* Saturday, April 13, 2.30 p.m., The Hotel Metropole, Leeds. Lecture: "The Electrical Engineer and Production," by Mr. A. F. Carter.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—*Student Section:* Wednesday, April 10, 6.45 p.m., Bolbec Hall, Newcastle-upon-Tyne, 1. "Superchargers," by Mr. Harry Chilton.

ROYAL AERONAUTICAL SOCIETY.—Friday, April 12, 6.30 p.m., The Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. "Flight Refuelling," by Sir Alan Cobham and Mr. Marcus Langley.

ROAD MARKING IN NEW SOUTH WALES.—The marking of traffic lines on the State highways of New South Wales has been completed over a distance of 1,250 miles. Yellow paint is used for the purpose, and it is sprayed on to the road by means of a special machine. It is stated in *The Commonwealth Engineer* that the average daily distance painted is over 10 miles, while the quantity of paint used varies from 12 gallons to 16 gallons per mile, according to the texture of the road surface. The marking of the lines is limited to bitumen-surfaced roads as concrete roads usually have a black centre joint and the gravel or earth roads cannot be effectively marked.

ELECTRIC CABLES AND FIRE RISKS.

(*For Description, see Page* 369).

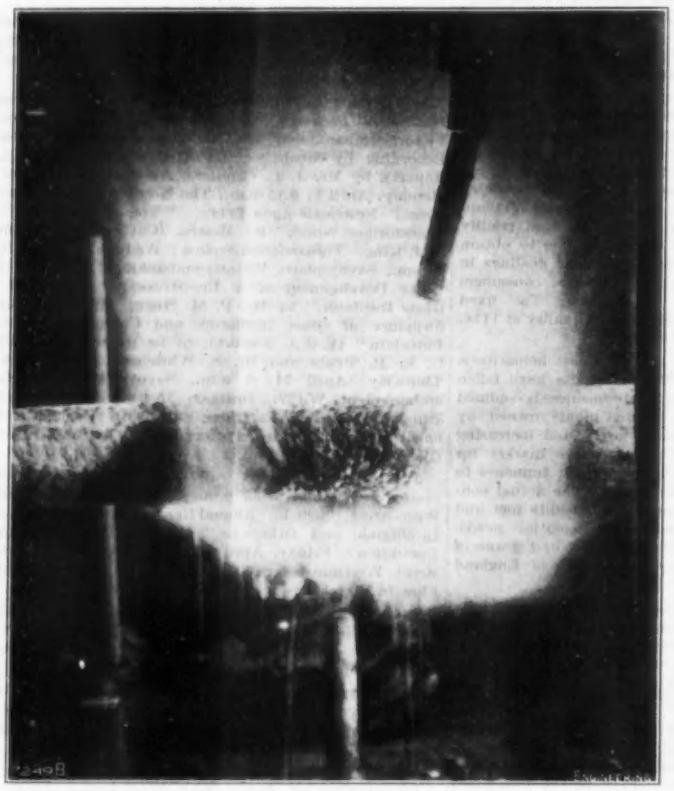


Fig. 1. Vulcanised-Rubber Cable 30 Seconds After Start of Test.

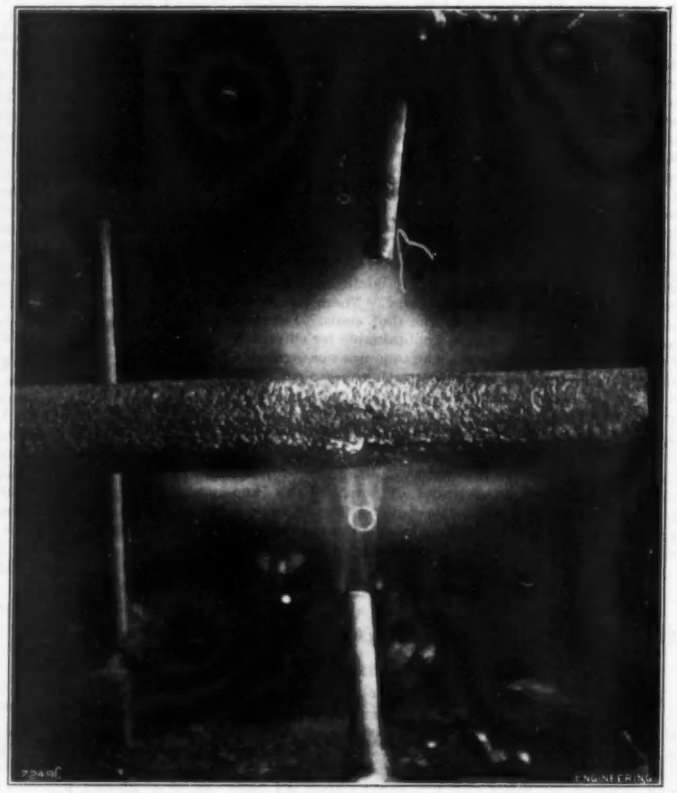


Fig. 2. Fire-Resisting Cable 30 Seconds After Start of Test.

Fig. 3. Vulcanised-Rubber Mining Cable After 10-Minute Test.

Fig. 4. Mining Cable After Removal of Wrappings.

Fig. 5. Paper-Insulated Lead-Sheathed Cable After Flame Test.

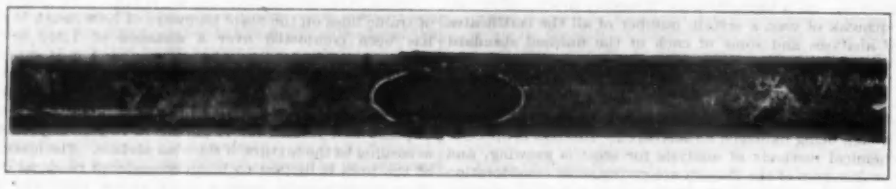


Fig. 6. Lead-Sheathed Cable After Removal of Bedding.

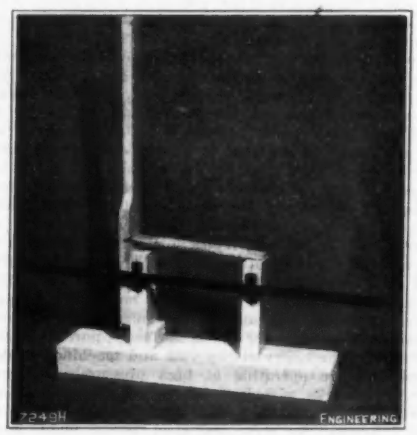
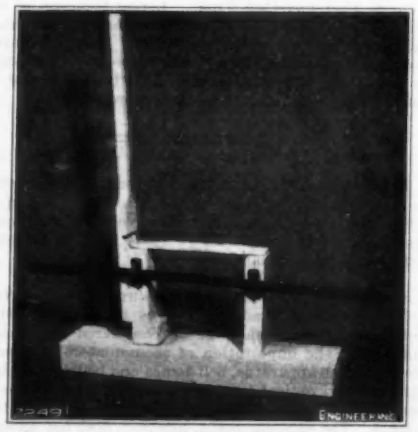


Fig. 7.



Figs. 7 and 8. Apparatus for Arcing Tests on Trailing Cables.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS { "ENGINEERING," LESQUARE LONDON.

TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance :—

For the United Kingdom	£3	5	0
For Canada—			
Thin paper copies	£2	18	6
Thick paper copies	£3	3	0
For all other places abroad—			
Thin paper copies	£3	3	0
Thick paper copies	£3	7	6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of Publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

CONTENTS.

	PAGE
Penstocks for Hydro-Electric Power Plants (Illus.)	349
Some Effects of Short-Circuits on Three-Phase Transmission Lines (*Illus.*)	352
Bonded-Rubber Flexible Coupling (*Illus.*)	356
Ventilation of Manholes	356
Phœnix Small-Part Finishing Machine (*Illus.*)	357
Annuals and Reference Books	358
British Standard Specifications	358
Tenders	358
Books Received	358
Personal	358
Notes from the North	358
Notes from the South-West	359
Notes from South Yorkshire	359
Notes from Cleveland and the Northern Counties	359
Notices of Meetings	359
The Past and Future of British Railways	361
Power in Agriculture	362
Notes	363
The Engineering Outlook—XI	364
The Late Mr. W. B. Woodhouse	366
The Late Sir John Gilmour	366
The Late Professor S. M. Dixon	366
The Iron and Steel Institute	366
Notes on New Books	367
Labour Notes	368
Electric Cables and Fire Risks (*Illus.*)	369
The Demolition of the "Mauretania"	370
Fifty Years of Marine Engineering (*Illus.*)	371
Combined Water Tap and Drinking Fountain (*Illus.*)	373
"ENGINEERING" Patent Record (*Illus.*)	374

Two One-Page Plates.—PENSTOCKS FOR HYDRO-ELECTRIC POWER PLANTS.

ENGINEERING

FRIDAY, APRIL 5, 1940.

VOL. 149. No. 3873.

THE PAST AND FUTURE OF BRITISH RAILWAYS.

THE speeches of the chairmen at the annual general meetings of the four main-line railway companies, which have been held recently, throw a good deal of light upon the past and present positions of these undertakings, and allow some prophecies to be made about their future. As the reports and the statements of accounts are sent to the shareholders some days previously, a detailed discussion of their contents is unnecessary at the meetings, and an opportunity arises, therefore, to dilate upon general principles of railway administration and other matters to a receptive audience. No chairman, of course, takes quite the same facet of the railway problem as his theme, and his remarks are, of course, coloured to some extent by the history of the particular company over which he presides. Nevertheless, even before the war the interworking of the four main-line systems was so close and their difficulties so similar that what was said about one might be applied without danger to the others. At the present time the similarity is even greater.

The history of the British railways during 1939 may be stated in a few words. Some depression was still evident in the first few months of the year, but in the spring better times set in, and by the end of June there had been a substantial recovery. In July and August the curve of improvement had become even steeper, when this almost halcyon state of affairs was abruptly terminated by the outbreak of war. Immediately, the railways passed under Government control; skeleton passenger services replaced those associated with the holiday period; similar drastic restrictions were imposed on the goods services, and, of course, there was a corresponding reduction in revenue. At the same time, the movement of troops and the demands of the evacuation scheme imposed special temporary loads upon all the systems to a greater or less extent. The second of these factors also had a more lasting effect, owing to the alterations which took place in the residences and places of business of large sections of the population.

Further financial strain was caused by the necessity for constructing protective works against enemy action from the air and for ensuring that, at night, lighted trains should not act both as guides and targets for hostile craft. In endeavouring to ensure safety in the latter direction, the railways, under Government pressure, again went too far, as they had done in the case of the passenger services. After an almost complete black-out of carriage lighting had been effected and the public had been unduly irritated thereby, modifications were introduced which certainly improved matters, though at considerable cost. To step outside the strict limits of 1939, as most of the chairmen allowed themselves to do, the weather in the early part of the present year imposed such a stress on all the railways that the breaking point was almost reached, while conditions in the North Sea threw a still greater load on two of the systems, owing to the necessity of arranging that more of the coal which London draws from the north-east coast should be carried by land instead of by sea. From the point of view both of the management and the public, therefore, railway history during the past year has been very far from normal. It is not unlikely that 1939 may mark a turning point in railway history; neither is it unexpected that, though the financial results of the year's working were better than in 1938, they were appreciably less than during the comparative prosperity of twelve months earlier.

The basis of most modern forms of transport is engineering; and railways especially are greatly dependent on the skill of engineers. Without them railways would never have been constructed, and could not continue to exist, much less develop. It is surprising, therefore, that so little attention was paid to this branch of the organisation by the chairmen, except on the score that what meets demands so efficiently may be allowed to escape criticism and even notice. Lord Stamp, in particular, gave a learned disquisition on the economics of railway management, in the course of which he pointed out that the train-miles per engine-hour on the London Midland and Scottish system had, in 1939, improved 0·8 per cent. over the previous year and by over 7 per cent. compared with 1929, while the wagon-miles run per engine-hour had increased by 9·36 per cent. during the same decade. He failed, however, to hint, much less to emphasise, that this improvement was largely due to the skill of his engineers, neither did he draw attention, even in the most general terms, to the methods by which these steps forward had been effected.

Sir Ronald Matthews, of the London and North Eastern Railway, dealt primarily with finance, though in the review issued at the meeting he did mention that work on the locomotive-testing station at Rugby had been postponed owing to the war. The omission of any more direct reference to engineering is the more notable since his officials have played a prominent part in recent advances in locomotive engineering. The same can be said of Lord Horne, when dealing with the fortunes of the Great Western Railway. Indeed, the only exception was Mr. Holland-Martin, of the Southern Railway Company, who gave a full account of what that undertaking has been doing in converting suitable portions of its systems from steam to electric working, a piece of work which has demanded a great deal of engineering ability. In the absence of similar information from the other companies, this item must stand by itself. That it should have to do so, however, is a pity, as there has been some engineering progress on all the railways, as engineers generally, and the public to some extent, are well aware.

Mr. Holland-Martin was also exceptional in keeping more closely than his colleagues to the subject of railway management, and in so doing gave some interesting facts. The Southern Railway is rightly regarded as being mainly a passenger line, so much so that in normal times 75 per cent. of its traffic is derived from that source and only 25 per cent. from goods. One result of this has been a much more widespread use of electric traction than on the other systems, so that 1,760 track-miles are now operated by that means. During the past five years, no less than 619 track-miles have been converted, the latest examples being the lines to Reading, Maidstone and Gillingham. The first of

these changes enabled the mileage run to be increased by 58 per cent., while in the case of the Maidstone and Gillingham line the corresponding figure was 42·7 per cent. Moreover, the passenger traffic in the electrified area increased during the year by 2·3 per cent., an improvement which did much to offset the almost complete disappearance of the Continental traffic, and the disturbance caused by military transport and evacuation.

Though the other three railways have not found in electrification an equally successful method of overcoming their troubles, some schemes have been put in hand, either individually or in co-operation with the London Passenger Transport Board. One of these, which should do much to increase facilities in North London, will be inaugurated this month, and others will soon follow. No mention of this was made, however, in the speeches of the chairmen concerned, though it is a move not with significance. Nor was anything said about the reasons for postponing the Manchester-Sheffield electrification on the London and North Eastern Railway, or for the rejection of a much more comprehensive scheme of main-line electrification on the Great Western. Great harm has been done to the cause of railway electrification by some of the more enthusiastic of its advocates; even so, it has its place in the scheme of things and before long its claims to recognition within its proper field may become more insistent. It would be well if attention had been called to these points, even if some of the observations on finance and economics had to be sacrificed.

Punctuality naturally suffered at the outset, but the lack of it appeared to persist for an unduly long time, on both main and suburban lines. In the unavoidable reduction of off-peak suburban services, too, largely caused by diversion of staff to other duties, more consideration might have been given to the needs of those whom petrol rationing deprived of the use of their cars for business purposes.

On the other hand, every chairman made much of the part played by the railways in carrying out the Government scheme of evacuation. On the Great Western Railway, it appears, 337 special trains were run for this purpose in four days, while on the Southern Railway 1,014 trains were needed to carry 300,000 evacuees. While not wishing in any way to detract from these feats, it must be pointed out that they were effected at the expense of the ordinary service. Such dislocation, however, was only temporary. Attention was called to the great increase in military and goods traffic, the effect of which on normal operation has been more profound, since it has had to be carried at the expense of the ordinary passenger traffic. Apparently, it had been expected that this ordinary traffic would fall to very low figures Actually, as Mr. Holland-Martin pointed out, the passenger traffic on the Southern Railway fell by less than 20 per cent., and time-tables more nearly resembling the normal had to be devised within a few days of the outbreak of war. The result was an increasing strain on all the systems, a strain which has been accentuated by a number of extraneous factors. Passengers, both casual and regular, therefore deserve the sympathy that has been expressed on their behalf for what they have had to endure, and may be forgiven for hoping that, within the framework of war-time conditions, that sympathy may lead to further improvement.

It would be hardly profitable to base any prophecies regarding future railway administration on the events and apparent tendencies of the past year. It may be recalled, nevertheless, that the war of 1914-18 led to the combination of the numerous railway companies, then existing, into four large groups, after they had been virtually under Government control for more than four years. It is not inconceivable that the present war will see a further step towards unification. Once again the railways of the country have been placed under Government control, and a scheme has been promulgated under which payment is to be made for their use by the Government during the period of hostilities. As is only natural, there is considerable difference of opinion whether the Government or the shareholders will gain most advantage from this agreement. One thing, however, seems clear. The Government is now more intimately interested than ever before in the prosperity of the railways. The broad outcome, when war ceases, is not difficult to foresee, though the details remain obscure. Indeed, to place the railways of the country under one management seems to be the natural, if not the obvious, step. Indeed, an even longer step is not inconceivable. For while railway interests view the agreement with mixed feelings, road interests regard it with openly expressed enmity. It is a disturbing feature, says a manifesto recently issued by the British Road Federation, that while road transport is restricted in such a manner that it cannot effectively compete with the railways, the Government are members of the railway partnership and have an interest in seeing that railway traffic is kept up at the expense of road transport. This is a clear, if one-sided, statement of the position, which, if it does nothing else, shows that in equity, when the war is over, the Government should once again leave the railways to their own devices. It would be clearly inequitable for a large, if not predominant, railway shareholder to use its administrative powers to control a rival. As a shareholder said at the London and North Eastern Railway meeting, co-ordination between road and rail interests, or nationalisation, are two issues which will have to be settled when things once again return to normal.

POWER IN AGRICULTURE.

In a leading article which appeared in Engineering of October 13, 1939, two questions were raised: Would all the land scheduled under the Government be broken up by the end of the autumn ploughing season, and was all the power plant available for the purpose in full use? Both were answered in the presumed negative. The debate on food production, which took place in the House of Commons on March 13, confirms that these doubts were well founded, and justifies some reconsideration of a subject which, in view of the close association of its major problems with engineering, and its outstanding importance at the present time, deserves that its technical aspects should enjoy at least equal priority with those of munitions production. The almost complete dependence of modern agriculture upon mechanical plant is a feature not commonly realised by the townsman, who represent so large a proportion of the population; but the fact remains that, if its present backward condition is to be amended and the required increase in output is to be achieved in the immediate future, the relevant section of the engineering industry must be encouraged to an extent apparently not yet envisaged.

It may satisfy Parliament to be told that the ploughing scheme is proceeding very well, and that the provision of mechanical plant and of labour, generally speaking, is adequate to requirements; but the short fact is that only 1,370,000 acres have been ploughed up and sown, instead of the 2,000,000 acres that were to have been dealt with, under the official scheme, by March 31 of this year. In productive value, according to *The Times* of March 26, this is only sufficient to provide the nation's food for about a day and a half: a figure which may prove to be more than offset by the loss, through stress of weather, of a large part of the winter-sown wheat. The yield of spring-sown wheat, it may be mentioned, is never as good as that sown in winter. There is little doubt that the main reason for the deficiency on the official acreage scheme is the failure to mobilise at once the whole of the available mechanical resources immediately upon the introduction of the ploughing bounty. A material proportion of the steam plant available is still demobilised, and seems likely to remain so unless prompt action is taken to put it into service. The hampering effect of the recent severe weather must be admitted, but it is by no means wholly responsible.

The whole question of steam power on the land merits much closer attention than has yet been devoted to it. In spite of its relative antiquity by comparison with the agricultural employment of internal-combustion engines, steam ploughing, cultivating and mole-draining is generally admitted to be the more effective method for heavy land. It has been driven out of common use by economic and working conditions which no longer exist, and which seem unlikely to return in the near future; there is every inducement, therefore, to bring the idle plant out of its enforced retirement and to put it to work at the earliest opportunity. There is a potential market at the present time to warrant an extension of the Government scheme from two million acres to ten millions, which could be achieved largely through a comprehensive system of land drainage—a task for which steam tackle is particularly suitable.

We have referred before to the possible effect of a temporary shortage of liquid fuel on an agricultural industry entirely dependent upon it; for this reason alone, and quite apart from any question of the relative quality of its work, steam plant, using home-produced fuel, should enjoy a wider favour. Repairs and renewals are also important considerations. Owing to the incessant "collar work"—ploughing has been likened to a perpetual ascent in low gear of a very steep hill—the life of an internal-combustion engine is short in agricultural service; some authorities place it at no more than three to four years, and the consumption of spare parts is heavy in proportion. The necessary complete renewals, and the maintenance of an adequate supply of spares, represent a severe tax upon the resources of an industry already heavily stressed by demands from other quarters. Purchasers from abroad, which must add to the enormous burden to be met from the available balance of the nation's foreign exchange, are naturally to be avoided if possible. From whatever angle it may be considered, the case for setting to work the numerous sets of laid-up steam plant is undeniably a strong one. It may be necessary to train additional crews; but there is ample scope for their recruitment—for example, among the enginemen formerly attached to travelling shows, many of whom are now out of work.

Other aspects of the question of agricultural steam power are those bearing upon threshing and carting. Too much reliance should not be placed on the ordinary standard tractor for such work; although it has sufficient power to drive the usual plant, consisting of a threshing drum and elevator, or a chaff-cutting box, in wet weather it lacks sufficient adhesion to move the drum about stackyards and fields, and is frequently at a disadvantage by comparison with the heavier steam engine, with its larger wheels. It may be questioned whether this practical detail has received due attention in the formulation of the Government schemes, and the same applies to the provision of adequate cartage equipment. A thousand acres of arable land requires, on an average, ten cartage vehicles, which should be low-loading, unsprung (but carried on pneumatic tyres), and adaptable without alteration to either horse or tractor haulage. Sprung vehicles are liable to jettison bulky loads, such as straw crops, when passing over ordinary rough field surfaces. The greater proportion of agricultural cartage consists of the harvested crops and, in consequence, represents a concentrated load restricted to a portion of the year, further limited by the need to await reasonably good weather.

Agriculture, like time and tide, waits for no man, and it is useless to try to average the requirements by passing plant from farm to farm; it must be at hand when the weather is favourable. In addition, there are two peak periods in the year when every farm of any size needs the whole of its appropriate equipment. During harvest, for example, a delay in waiting for a reaping outfit from a neighbouring farm might cause the loss of half the grain yield, by "shelling-out" during the cutting of over-ripe grain; in fact, the farmer's best efforts, even with all the equipment at hand, frequently require to be supplemented by any outside assistance that he can muster. In brief, a material increase in arable acreage predicates a corresponding increase, not only in tractors, but in all the plant necessary for ploughing, harrowing, seeding, reaping, cartage and threshing. Only in threshing is any considerable "spread-over" practicable. Finally, it may be observed that the above comments apply to the crop of 1941-42; the opportunity for this year, and the first three quarters of the next, is already lost.

NOTES.

LABOUR IN WAR INDUSTRIES.

AN important step towards the more efficient employment of our industries in the present national effort was taken by the Ministry of Supply at the beginning of this week. By the Factory Undertakings (Record and Information) (No. 1) Order, 1940, employees in the engineering, motor-vehicle and aircraft-manufacturing industries, and those engaged in ship building and repair, are required to furnish specified information regarding the products manufactured by them and the labour they employ. This information must be given by Wednesday, April 10, and will consist of particulars of each undertaking's main, normal or peace-time products and of the main products which have been, or are being manufactured, on Government account. Information is also to be given as to the approximate percentage of the total labour which is being employed on Government work, for the export trade and for the home market. In addition to the total number of men, women, boys, and girls employed now and in June, 1939, there must be a numerical classification in certain broad occupational groups, from which office staffs and salaried persons will be excluded. The three main purposes of this census are stated to be to provide information of the proportion of the labour in certain vital industries which is employed on production for the war effort or in the export trade or for the home market, to yield valuable information as to the distribution of skilled labour among the various industries, and to assist the Area Supply Boards in dealing with problems connected with the planning of production. It is understood that, though the returns will be compulsory, those supplied by individual firms will be treated as confidential. Future returns will be required, not only from firms in the industries already named, but also from others, and it is expected that the second complete return will be called for at the beginning of June.

OVERSEAS AIR-MAIL SERVICES.

On Monday, April 1, the undertakings of Imperial Airways, Limited, and British Airways, Limited, were acquired by the British Overseas Airways Corporation, about whose immediate policy a statement was made by the chairman, Mr. Clive Pearson, last week. Progress, he said, would depend entirely on war conditions, but it was not likely that a North Atlantic service would be begun this year, though mails would be carried. This service was likely to start soon after the base in Newfoundland was clear of ice, which would be towards the end of May. The South Atlantic project of British Airways would be held in abeyance. Meanwhile, the Corporation would buy a limited number of D.H. 95 aeroplanes of the Flamingo type, and would maintain a constant watch on commercial aircraft development, so that at any moment it would be able to issue up-to-date specifications. Mr. Pearson admitted that there had been in the past some lack of decision and drive in the development of British commercial flying. He instanced the failure to recognise the shortcomings of Croydon as a London airport, and the confusion over the Langstone Harbour project. Fundamentally, however, the fault lay not with the operating companies but with previous Governments. As regards obtaining new aircraft from British manufacturers, the military demands of the Government necessarily came first. He especially directed attention to the value of commercial air lines to the export business of the country. Every line running to a neutral country had a prestige value and was a means of sending out samples and companies' representatives. It was mentioned that the permission of the Spanish Government to run a service to Lisbon was to be expected shortly, and then the institution of the line would not take more than three or four weeks.

ELECTRICITY SUPPLY IN IRELAND.

The recent account of the present position of electricity supply in Ireland, given by Dr. T. A. McLaughlin and published in ENGINEERING for March 1, 1940, may be supplemented by some remarks of Mr. Sean MacEntee, Minister for Industry and Commerce at a meeting of the University College (Dublin) Engineering Society. He envisaged the interconnection of the systems of Eire and Northern Ireland; a step which, though not meaning that the interchange of power in normal circumstances would be very large, would enable the amount of stand-by plant to be reduced and continuity of supply to be secured at a less cost than at present. Discussing the power resources of the country, Mr. MacEntee said that investigations had shown the erection of a peat-burning station to be quite practicable. As its capacity would not exceed 25,000 kW, however, it would go but a little way to meet the increasing demand. Next to the Shannon and the Liffey, the Erne and the Boyne were the most important rivers from the hydro-electric point of view. The Boyne might give 100 million kilowatt-hours and the Erne 200 million kilowatt-hours per annum, or almost six times that obtainable from the Liffey in an average year. In this case, however, high rates of compensation were a difficulty, and the storage facilities lay within the area of the Northern Government. That a combination of hydro-electric and thermal stations was essential seemed clear from the experience of the Electricity Supply Board. The proportions in which the two types of stations would contribute depended on the weather, but if the load could be so developed as to make it possible to utilise the water available in a wet year, from 450 million to 600 million kilowatt-hours could be obtained from the Shannon. The Shannon scheme had reduced their dependence on foreign fuel by 220,000 tons of coal yearly, but the cost of importing this fuel was increasing and for this reason the building of a peat-fired station would be undertaken with the greatest expedition.

EXPORT TRADE IN INTERNAL-COMBUSTION ENGINES.

A number of Government pronouncements have been made on the importance of maintaining export trade throughout the war, and on February 13 the President of the Board of Trade announced the constitution and composition of an Export Council which he had established to further this object. In a White Paper entitled "Aims and Plan of Work of the Export Council," published on March 6, the procedure of the Council was described in detail, and it was stated that the establishment of Export Committees or Groups for individual industries was regarded as vital. The Council would co-operate with such groups, and delegate to them the detailed work with individual firms which was involved in the national export drive. So far as the internal-combustion engine industry is concerned, the Internal Combustion Engine Manufacturers' Association was already in existence, having been established in November, 1939, and it was only necessary, in order to give effect to the recommendations of the White Paper, to constitute the Association a self-governing War Export Group under the name of the Internal Combustion Engine War Export Group. The constitution, aims and objects of this group are set out in a pamphlet known as the I.C.E.W.E.G. Red Book, published from the offices of the Group at 32, Victoria-street, Westminster, S.W.1. As originally constituted, the Association covered principally the manufacture and sale of stationary land engines of all types and sizes, marine engines not exceeding 1,500 brake horse-power (with the exception of such engines made by automotive or aeroplane makers), and Diesel locomotives. The War Export Group, however, include within their activities all other internal-combustion engine ranges not included within the scope of any other group. The Internal Combustion Engine Group, which is under the chairmanship of Sir Lynden Macassey, decided to extend membership to all manufacturers of engines, within the ranges already mentioned, without imposing upon them any obligation to join the Association, provided they agreed to pay their proportion of the expenses of the Group. The executive committee of the Group have already commenced to consider the various circumstances which, under present conditions, restrict the export trade in internal-combustion engines, and what action can most effectively be taken to promote and develop such export trade. An export-trade materials committee has been appointed to investigate and to make recommendations as to the best way of meeting the difficulty of securing a continuous and adequate supply of the necessary materials to maintain the export trade, and the scheme evolved is described in detail in the Red Book.

CANALS IN WAR TIME.

Inevitably the war has brought about a considerable interruption in the normal flow of coastwise sea transport, with the result that large quantities of coal, which were formerly carried by sea between north-east coast ports and London, now have to be borne by an already heavily-loaded railway system. As it is desirable that something should be done to relieve this strain, a letter by Mr. George Cadbury, in a recent issue of *The Times*, and a statement made last week by Mr. E. J. Woolley at the annual general meeting of the Grand Union Canal Company are worth close and early consideration. Mr. Cadbury argues, quite rightly, that in times of national emergency all forms of transport should be utilised to the utmost, but points out that, while the railways maintain certain of their rates at a low and even uneconomic level, canal carriers, though faced with rising costs, are compelled either to relinquish traffic because it does not pay or to charge higher rates at the risk of losing it. In addition, traffic is constantly being diverted owing to difficulties at the ports or because the methods of distribution are altered by the Ministry of Supply. The probable result is that carriers will soon be forced out of business. This argument is emphasised by some data given by Mr. Woolley. While, he said, up to the outbreak of war the revenue of the Grand Union Canal Company was 3,000*l.* greater than during the corresponding period in 1938, on the year's working there was a decrease of no less than 4,757*l.* In the last four months of the year the tonnage fell by 131,515, a result which is ascribed mainly to the diversion of ships to other ports, though the cessation of a regular service from Germany, the falling-off of the timber trade, and the stoppage of the coastwise coal traffic, mention of which has already been made, were also factors. In all, the total loss of revenue from tolls and dock dues was 8,800*l.*, a result which was entirely due to the war. To remedy this state of affairs, Mr. Cadbury recommends that the Government should take control of the main waterway routes, as it did in the last war, and that this assumption of responsibility should be accompanied by some form of guarantee to canal owners and operators on the same lines as has been done already with the railways. Income and expenditure should also be pooled and, indeed, the railway analogy should be generally followed. We are, therefore, glad to learn from the Minister of Transport that the Government has offered "some measure of financial assistance" if plans for conveying more traffic by canal can be formulated. At the present time the country can afford to neglect any form of transport and the canals could be used, to an appreciable extent, to relieve the present stress on the railways.

THE ALBERT MEDAL.—The Council of the Royal Society of Arts are to consider the award of the Albert Medal of the Society for 1940 early in May. The Medal was struck to reward distinguished merit in promoting arts, manufactures and commerce, and has been awarded annually since 1864. Among the recipients have been Michael Faraday, Sir Joseph Whitworth, the Vicomte de Lesseps, Sir H. Bessemer, Sir C. W. Siemens, Lord Armstrong, Lord Kelvin, Dr. J. P. Joule, Dr. John Percy, Sir Charles Parsons, the Marchese Marconi, Sir Dugald Clerk, Lord Rutherford, Sir Robert Hadfield and Lord Nuffield.

REGISTER OF EX-BRUSH AND PETTER PUPILS AND APPRENTICES.—Messrs. The Brush Electrical Engineering Company, Limited, Loughborough, inform us that they are frequently approached by old pupils who served their time either in their works or in those of their associated company, Messrs. Petters, Limited, with regard to the preparation of a pupils' register. The firm has a register of Petter apprentices which, however, is not up to date, and they also possess the addresses of many old Brush men, but in this case also the information is incomplete. The Brush Company, therefore, request all ex-Brush and Petter pupils, students, or apprentices to communicate with them in connection with the preparation of a register.

THE ENGINEERING OUTLOOK.

XI.—Marine Engineering.

Marine engineers were again very busy in 1939, though in the earlier part of the year, at any rate, their prosperity was based largely on the amount of armament work in hand. At the beginning of the year, merchant shipbuilding had fallen to an extremely low level, and this was reflected in the fact that the total horsepower of marine engines under construction (according to Lloyd's Register) amounted to 726,020, as compared with nearly 1,000,000 h.p. at the beginning of 1938. The usual quarterly figures have not been published for 1939, but the marine-engine builders derived considerable benefit from the revival of mercantile shipbuilding as a result of the Government proposals for the assistance of the shipping and shipbuilding industries, which were announced in March. On the basis of the shipbuilding figures it would seem probable that new orders for marine engines in the summer of 1939 were higher than at any time since 1930. The necessity since the outbreak of war for utilising the merchant shipbuilding capacity of the country to the full has still further increased the demand for marine engines.

Had it not been for the Government assistance measures referred to above, and the subsequent outbreak of war, it seems likely that merchant shipbuilding activity in this country would have fallen to a level comparable with that of the depression years, 1932 and 1933. The experience of the shipping industry throughout 1939, up to the outbreak of war, was definitely unsatisfactory. As shown in Table I, herewith, the stability of freight rates which had been a feature of 1938 was not maintained in the early months of 1939, and the index of shipping freights, on the basis 1935 = 100, which had fluctuated between 120 and 130 in 1938, fell to 117·5 in March. That the fall was not considerably greater was undoubtedly due to the voluntary scheme for the maintenance of minimum freights and the regulation of tonnage operated by the Tramp Shipping Administrative Committee. In several markets, notably the River Plate trade, business was practically non-existent in the first two months of the year and charterers maintained that no business could be done at the minimum schedule rate of 25*s.* per ton. In March, several foreign vessels were fixed as a result of the Spanish demand for Argentine wheat, and it was generally stated that this business has been secured by disregarding the minimum rate, which, therefore, was drastically reduced to 20*s.*

In April and May there was some recovery, but this proved to have been due to special factors—the demand for wheat in Spain as a result of the termination of the Spanish war and increased purchases for storage by the British Government—and was comparatively short-lived. The recovery was reflected in quite a sharp rise in the index of shipping freights in May to 129·6, compared with 119·6 in April, but it was not maintained in the following months. Throughout this period no subsidy was payable, although freight rates were lower than the level at which the maximum subsidy would have become payable in 1940 under the Government assistance scheme. Under the previous subsidy arrangement, the year 1929 had been taken as the basis year for the assessment of subsidy payments and it is interesting, therefore, to compare experience in 1939 with that in 1929. On the basis of 1929 = 100, the index for 1939 varied between 88 and 92, with the single exception of the month of May, when it stood at 97·1. Although it was not definitely stated that the Chamber of Shipping index would be used for calculating subsidy payments, it was understood that these payments would probably be made at the full rate if the index, 1929 = 100, fell below 95, and that they would cease if the index rose above 105. The full rate of subsidy, therefore, would have been payable throughout 1939, with the exception of the month of May.

The depression in the early part of the year was also reflected in the figures for tonnage laid up in United Kingdom ports, shown in Table II, on this page. These figures, which had reached the high level of 455,700 net tons on October 1, 1938, showed only a slight improvement at the beginning of 1939 to 452,400 net tons on January 1, and 417,700 net tons on April 1. There was, however, a more important reduction in the second quarter of the year to 281,900 net tons on July 1.

The improvement in the position regarding the employment of tonnage was also reflected in the statistics for tonnage engaged in British overseas trade. For the period January to April, 1939, the figures for tonnage entering British ports with cargo were below the corresponding figures for the previous year; from May to August, however, the position was reversed and, in July, in particular, there was an increase of 8 per cent. Taking the first eight months of the year as a whole, the monthly average for tonnage entering United Kingdom ports was 5,728,000 tons, against 5,715,000 tons for 1938.

The shipping depression was reflected particularly severely in the shipbuilding industry and the tonnage of vessels on which construction commenced fell to 71,000 in the first quarter of 1939, the lowest figure for any quarterly period since 1933. Moreover, the tonnage commenced had been declining steadily since the second quarter of 1937, so that, by the end of the first quarter of 1939, the tonnage of ships under construction was only 597,000, as against a capacity for mercantile shipbuilding construction of about 2,000,000 tons.

In view of the seriousness of the position, the Government proposals were announced at the end of March. These provided for a subsidy for deep-sea and near-Continental tramps, with a maximum of 2,750,000*l.* per annum, to be made available for a period of five years starting with 1940. As explained above, the actual subsidy payments were to be governed by a sliding scale based on freight rates. As a condition of receiving the subsidy, the Government expected the industry to continue its efforts to promote an international agreement with the object of adjusting the supply of tonnage to the demand. Secondly, an Advisory Committee was to be set up for an experimental period of two years to examine and advise the Government on requests for assistance from liner companies whose services were endangered by foreign competition. This proposal took the place of the Liner Defence Fund of 5,000,000*l.* per annum demanded by the industry.

The remaining provisions of the Government scheme related to the encouragement of shipbuilding and the creation of a reserve of tonnage against the possibility of war. As regards the former, a grant not exceeding 500,000*l.* per annum was to be made available to owners of tramps and cargo liners in order to encourage them to place new orders with shipbuilders. The grant was to be available for five years with the exception of any year in which earnings were insufficient to justify such public expenditure. In addition, the sum of 10,000,000*l.* was to be made available for loans on favourable terms to shipowners for the purpose of building tramps and cargo liners, other than refrigerated and passenger vessels. For the purpose of creating a reserve of tonnage the Government proposed to make available the sum of 2,000,000*l.* for the purchase of suitable ships which, though still capable of service, would otherwise be sold abroad or for breaking up. This proposal followed closely the scheme put forward by Sir Philip Haldin, which was referred to in this series last year. These proposals were embodied in the British Shipping (Assistance) Bill, but, owing to the pressure of Parliamentary business, it was not possible to pass the Bill through all its stages before the adjournment. It was intended to take the Committee stage of the Bill on October 3, but owing to the outbreak of war the proposals never became law.

Nevertheless, although most of the proposals designed to benefit the shipping companies were not in any case to come into effect until 1940, the effect on shipbuilding was very considerable. In the second quarter of 1939, as shown in Table III, above, work was started on 402,000 gross tons

Table I.—*Index Numbers of Shipping Freights.*

—	Old Series. 1924 = 100.	New Series. 1935 = 100.
1929	84	133·5
1930	65	—
1931	67	—
1932	64	—
1933	61	—
1934	64	—
1935	64	100·0
1936		112·6
1937		175·6
1938		126·9
1939—		
January-July		121·9
1938—		
January		138·2
February		129·5
March		127·5
April		126·9
May		130·6
June		123·1
July		120·2
August		126·4
September		126·3
October		127·6
November		122·3
December		124·1
1939—		
January		120·8
February		121·5
March		117·5
April		119·6
May		129·6
June		121·5
July		123·0

Table II.—*Idle Tonnage (Chamber of Shipping) of the United Kingdom.*

Date.	Net Tonnage.	Date.	Net Tonnage.
1930—		1935—	
January 1	360,000	January 1	883,300
April 1	918,000	April 1	705,700
July 1	935,000	July 1	599,100
October 1	1,002,000	October 1	512,300
1931—		1936—	
January 1	1,503,000	January 1	435,600
April 1	1,920,000	April 1	473,900
July 1	2,044,000	July 1	502,°00
October 1	2,089,000	October 1	402,900
1932—		1937—	
January 1	1,966,000	January 1	212,400
April 1	1,800,000	April 1	90,300
July 1	2,196,000	July 1	61,200
October 1	2,182,000	October 1	99,500
1933—		1938—	
January 1	1,971,000	January 1	174,600
April 1	1,836,000	April 1	339,300
July 1	1,946,000	July 1	332,000
October 1	1,572,000	October 1	455,700
1934—		1939—	
January 1	1,240,000	January 1	452,400
April 1	1,079,000	April 1	417,700
July 1	1,042,000	July 1	281,900
October 1	818,000		

Table III.—*Shipbuilding; Great Britain and Ireland.*

—	Vessels Commenced.	Vessels Launched.	Vessels under Construction (at end of quarter).
	Gross tons.	Gross tons.	Gross tons.
1913	466,582	485,038	2,002,699
1930—			
1st Qr.	426,570	344,699	1,614,993
2nd ,,	230,466	468,023	1,392,063
3rd ,,	160,714	378,585	1,116,746
4th ,,	131,995	296,843	908,902
1931—			
1st Qr.	33,000	146,000	694,000
2nd ,,	23,000	170,000	556,000
3rd ,,	39,000	80,000	417,000
4th ,,	105,000	71,000	401,000
1932—			
1st Qr.	25,700	35,000	373,000
2nd ,,	28,000	69,000	281,000
3rd ,,	10,800	48,000	238,000
4th ,,	7,400	35,000	230,000
1933—			
1st Qr.	77,000	13,000	252,000
2nd ,,	50,000	11,000	287,000
3rd ,,	40,000	42,000	304,000
4th ,,	75,000	65,000	331,000
1934—			
1st Qr.	203,000	35,000	481,000
2nd ,,	147,000	36,000	587,000
3rd ,,	77,000	183,000	604,000
4th ,,	93 000	207,000	597,000
1935—			
1st Qr.	144,386	106,097	558,815
2nd ,,	108,122	116,011	560,321
3rd ,,	118,979	112,840	530,554
4th ,,	311,100	132,139	743,086
1936—			
1st Qr.	232,523	194,275	842,361
2nd ,,	282,322	167,958	848,732
3rd ,,	293,176	212,087	928,571
4th ,,	272,546	280,397	963,642
1937—			
1st Qr.	253,493	175,686	1,014,454
2nd ,,	367,698	252,608	1,199,973
3rd ,,	218,557	269,558	1,184,635
4th ,,	217,497	223,496	1,125,426
1938—			
1st Qr.	173,031	179,992	1,089,077
2nd ,,	156,970	236,733	1,037,073
3rd ,,	87,463	309,770	885,481
4th ,,	87,632	241,627	779,762
1939—			
1st Qr.	71,000	158,000	597,000
2nd ,,	402,000	138,000	791,000

of shipping, nearly six times the figure for the first quarter of the year and the highest recorded since the first quarter of 1930. This brought the tonnage under construction at the end of June up to 791,000 gross tons.

The tanker situation, regulated by the International Tanker Pool, showed little change in 1939 up to the outbreak of war. In June it was announced that the contribution rates, which had been advanced in October, 1938, by 2½ per cent. to 12½ per cent. for voyage charters and 15 per cent. for time charters, would be maintained at this level. For the ninth accounting period, to November 3, 1938, allowances in respect of laid-up tonnage were paid at the rate of 14*s.* 4½*d.* per ton, very little below the maximum permissible allowance of 15*s.* For the following period, to May 3, 1939, an interim distribution of 7*s.* 6*d.* was made, and Mr. H. T. Schierwater, the chairman of the International Tanker Pool, stated that the receipts should be ample to enable the maximum payment to be made for the full year. He found it necessary, however, to deliver a warning against the over-building of tanker tonnage, in spite of the fact that, according to the shipbuilding returns of Lloyd's Register, there had been already quite a considerable fall in the tonnage of tankers under construction in the world, from 926,510 gross tons at the end of June, 1938, to 634,665 gross tons at the corresponding date in 1939.

The whole of the shipping position, of course, was radically changed on the outbreak of war, since the problem then became a shortage of ships in place of the surplus which had prevailed in peace time. The Government announced that it would not proceed with the British Shipping (Assistance) Bill, but that applications for loans on vessels already ordered would be considered. The Ministry of Shipping began the requisitioning of tramps in December, 1939, and this policy has been extended since, while deep-sea liners were requisitioned as from February 1. The rates of hire for requisitioned vessels have not yet been finally settled and the protracted negotiations have been causing some anxiety to shipowners. In particular, this anxiety is centred on the allowance to be made for replacement and the need to prepare for intensified competition after the war. It has been pointed out that, as a result of their strong bargaining position, neutrals have been securing preferential rates of freight, as a result of which they are likely to be able to adopt a progressive renewal policy which will place them in a much stronger position at the end of the war.

TABLE IV.—MERCHANT SHIPPING UNDER CONSTRUCTION, 1938 AND 1939.

	1938.			1939.		
	Total.	For Export.	Percentage of Total for Export.	Total.	For Export.	Percentage of Total for Export.
Great Britain	1,037,073	176,046	17·0	791,455	108,333	13·7
Germany	396,953	184,540	46·5	347,832	113,156	32·6
Holland	280,816	31,367	8·2	223,381	32,169	14·5
Sweden	114,675	79,175	69·1	160,620	104,500	65·1
Denmark	107,075	68,625	64·1	122,440	104,410	85·4
Italy	136,785	94,550	69·2	224,616	98,350	43·6

TABLE V.—*Marine Engineering; Total Employment, United Kingdom.*

Date.	Number Insured.	Number Unemployed.	Number Employed.
July, 1929	58,450	5,211	53,239
,, 1930	60,670	9,347	50,723
,, 1931	55,240	26,224	29,016
,, 1932	50,530	29,274	21,256
,, 1933	46,220	21,833	24,387
,, 1934	46,750	13,621	33,139
,, 1935	45,650	12,049	33,601
,, 1936	49,960	6,013	43,947
,, 1937	53,780	4,391	49,389
,, 1938	57,180	4,247	52,933
,, 1939	59,940	3,963	55,977

TABLE VI.—UNITED KINGDOM; EXPORTS OF MARINE ENGINES AND MACHINERY. (£000.)

	1930.	1931.	1932.	1933.	1934.	1935.	1936.	1937.	1938.	1939 (Jan.-Aug.)
1. *Steamships*:—										
Reciprocating engines	1,311	520	245	101	160	221	336	465	751	} 450*
Turbines	683	831	176	81	—	67	92	37	2	
Boilers	837	503	201	84	83	104	229	199	374	
Other machinery	633	591	232	186	61	155	196	163	212	
2. *Motorships*:—										
Engines	2,899	813	65	44	85	197	308	153	560	} 440*
Other machinery	464	163	49	8	63	64	86	37	184	
Separate.										
Steam reciprocating	169	74	28	25	31	27	23	41	151	36*
Internal combustion	477	237	223	364	395	378	403	501	617	369
Steam turbine†	—	—	—	—	—	—	—	—	225	222*
Total	7,473	3,722	1,319	895	877	1,233	1,673	1,596	3,076	1,517

* Estimates. † Not separately recorded prior to 1938.

Turning to the position of shipbuilding, the position up to June, 1939, has already been outlined. Undoubtedly, the proposals embodied in the British Shipping (Assistance) Bill have been of the greatest importance from the strategic point of view, since without them the country would have entered the war with a high proportion of berths empty. Immediately on the outbreak of war, of course, shipbuilding came under Government control, and as from February 1, 1940, the production and repair of naval and merchant vessels has been co-ordinated under the Admiralty. It is hoped to increase the output of mercantile tonnage to at least 1,500,000 tons per annum. In this connection it may be noted that losses by enemy action during the first five months of the war totalled 549,661 gross tons, equivalent to some 1,300,000 tons per annum. This clearly leaves only a small margin to counterbalance a possible increase in losses if submarine and air activity are increased in the summer months. The possibility of restarting some of the dismantled yards has not been entirely ruled out, but initially, every effort is to be made to secure the maximum output from the existing yards. When the redundant yards were closed it was stipulated that they were not to be used for shipbuilding for a long term of years; but the Minister of Shipping has stated that these restrictions would not be a limiting factor in the shipbuilding programme. While the majority of the closed yards have been completely dismantled, a few have been kept on a care and maintenance basis. In the initial stages, undoubtedly, the major problems will be to ensure adequate supplies of labour and materials. In no recent year has the total output from British yards materially exceeded 1,000,000 gross tons, and it is necessary to go back to 1930 for a year in which launchings approached 1,500,000 gross tons. Moreover, naval shipbuilding, which was comparatively unimportant in 1930, has now reached a very high level and is likely to be given priority in the allocation of supplies of labour and materials.

It is not possible to give, as has been done in previous years, a table for international launchings for 1939, together with the proportion of the total in each country launched for export, but Table IV, on this page, shows the tonnage of vessels under construction and the proportion of that tonnage being built for export in the principal countries at June 30, 1938, and June 30, 1939. It will be seen that, in Great Britain, in spite of the large fall in the total amount of construction in hand, the fall in work for export was even greater, and the proportion of tonnage under construction for export fell from 17 per cent. of the total in 1938 to 13·7 per cent. in 1939. In Germany, the proportion fell from 46·5 per cent. to 32·6 per cent., but in this case the fall in the total tonnage under construction was much less, from 396,953 gross tons in 1938 to 347,832 gross tons in 1939. In Holland, Sweden, Denmark and Italy, the tonnage of merchant vessels under construction for export increased. Taking all the countries shown in Table IV together, construction for export declined from 634,303 gross tons to 560,918 gross tons. To some extent, no doubt, the decline in British work for export was due to a further rise in shipbuilding costs. According to the report of the Chamber of Shipping for the year 1939-40, discussed in a leading article on page 283, *ante*, a ship which cost 100,000*l.* in 1938 cost 120,000*l.* immediately before the war and 160,000*l.* in February, 1940.

In the early part of 1939 the marine-engineering industry owed a great deal of its activity to the work on hand in connection with naval shipbuilding, and, in spite of the substantial recovery in mercantile work later in the year, naval shipbuilding must have continued to employ a large part of the capacity of the industry. In introducing the Navy Estimates for the year 1939-40, the Parliamentary Secretary to the Admiralty stated, in March, 1939, that British dockyards and shipbuilding yards would be engaged during the course of the year in building some 200 vessels of a total of 870,000 tons. This total included 9 battleships, 6 aircraft carriers, 25 cruisers, 43 destroyers and 19 submarines. The figure for naval tonnage under construction showed a very marked expansion during the year 1938-39, and compares with 547,104 tons in March, 1938, 375,740 tons in 1937, and 281,925 tons in 1936. No figures have been given for tonnage under construction at dates more recent than March, 1939, but, undoubtedly there has been a marked expansion during the past year and there can be little doubt that the figure is now over 1,000,000 tons. Even before the outbreak of war it was anticipated that an average of 220,000 tons a year would be completed in 1940 and 1941.

As a result of the increased naval work and the revival in mercantile shipbuilding, employment in marine engineering increased from 52,933 at July, 1938, to 55,977 at July, 1939, as shown in Table V, on this page. The shortage of labour in the industry is shown by the fact that, in spite of an increase in the number insured of nearly 2,800, there was a further fall in unemployment from the already low figure of 1938. By the end of 1939 the number unemployed had fallen still further to 2,060, the lowest figure ever recorded in the industry and representing little over 3 per cent. of the number insured.

British exports of marine engines and machinery are shown in Table VI, on this page. After showing a substantial increase in practically all categories in 1938, these probably fell back somewhat in 1939 owing to a fall in the exports of ships. It should be noted that, with the exception of those for internal-combustion engines exported separately, all figures for exports in 1939 are estimates only, based on the number and value of ships exported or, in the case of separate machinery, on total exports of steam reciprocating engines or steam turbines. A notable feature of marine engineering during 1939 was that, although the proportion of world merchant tonnage burning coal continued to decline, new construction of steamships showed a considerable increase in relation to that of motorships. A considerable proportion of the steamship tonnage built in the United Kingdom was designed for dual firing.

In the absence of complete figures for marine-engine construction by districts, it is of interest to examine the figures for tonnage of merchant vessels

under construction by districts at June, 1939. Practically all the principal districts showed a decline in activity in 1939; in the case of the Clyde from 419,608 gross tons at June 30, 1938, to 355,341 gross tons at the corresponding date in 1939; of the Tyne, from 158,608 gross tons to 91,036 gross tons; of the Wear, from 125,737 gross tons to 118,955 gross tons; and of Belfast, from 117,700 gross tons to 88,220 gross tons. The Wear thus took second place in importance, although only a few years ago the amount of work in hand was practically negligible.

THE LATE MR. W. B. WOODHOUSE.

Electrical engineers will learn with regret of the sudden death of Mr. W. B. Woodhouse, which occurred at Bramhope, near Leeds, on Sunday, March 31, at the age of sixty-six. Mr. Woodhouse had been connected all his life with the electricity supply branch of the industry, and had played a leading part in the development of the use of electric power in Yorkshire and other parts of the north of England.

William Bradley Woodhouse was the youngest son of Mr. Thomas Woodhouse, of Dalmuir, and after leaving school received his electrical training at Finsbury Technical College under Silvanus Thompson, and at University College, London. He served his apprenticeship with the India Rubber and Gutta Percha Company, Limited, at Silvertown, and subsequently held positions with Messrs. John Davis and Sons and Messrs. Marks and Clerk. In 1896, he became lecturer on mechanism and mathematics at Finsbury Technical College, but after occupying this post for four years began his long connection with the electricity industry by joining the Newcastle-upon-Tyne Electric Supply Company as electrical assistant and resident engineer. In October, 1903, he left Newcastle to become chief engineer of the newly-formed Yorkshire Electric Power Company, a position he held until 1935, when he was appointed managing director.

The Yorkshire Electric Power Company is one of the undertakings which was formed as the result of the recommendations of a Joint Committee on Electrical Energy (Generating Stations and Supply), which sat at the end of last century. This body, which is generally known as the Cross Committee from the name of its chairman, reported in favour of giving powers to companies, formed for the purpose, for the supply of electricity over large areas from "plant of exceptional dimensions and high voltage." These companies were not to be subject to purchase by the local authorities in whose areas they operated, but were only allowed to supply either in bulk to existing undertakings or to large consumers whose requirements were mainly for power. In practice, the lot of these companies was initially somewhat unhappy. They could not compete with the municipal undertakings supplying in the areas governed by those bodies, with the result that their only fields of operation were the sparsely-populated semi-urban and rural districts surrounding the large towns. Even in these districts a supply for all purposes could not be given without the consent of the local authorities concerned, which either acted as their own distributors or, as was the case in Yorkshire, through a separate distribution company. This restriction on what might otherwise have been the useful activities of the power companies was particularly emphasised by the Coal Conservation Committee, which was appointed during the war of 1914-18, and on the whole their positions were greatly improved by the Electricity (Supply) Acts of 1919 and 1922. Still further benefits were conferred upon them by the Electricity (Supply) Act of 1926, which, it will be remembered, envisaged the generation of the electrical requirements of the country in a limited number of large stations. As a high proportion of the then existing stations which could be so described were owned by the power companies, it was evident that these would fall into the "selected" class, and this has been particularly true of the stations at Barugh, Ferrybridge and Thornhill, of the Yorkshire Power Company, which were designed by Mr. Woodhouse. The lean years of the early days of the power companies have also changed into prosperity with the great development that has taken place in the use of electricity for all purposes. At the present time, in fact, the Yorkshire Power Company is one of the largest electricity supply undertakings in the country, being responsible for the generation of some 600 million kilowatt-hours in the year ended December 31, 1938. For this development, Mr. Woodhouse can be truly said to have been largely responsible.

Mr. Woodhouse was elected a member of the Institution of Civil Engineers in 1919, while his connection with the Institution of Electrical Engineers began in 1902, when he became an associate-member. He was transferred to the class of member in 1913 and, after serving on the Council and as chairman of the North Midland Centre, was elected president in 1924. He was also a member of the Institution of Mining Engineers and a past-president of the British Electrical Development Association. During the 1914-18 war he acted as electrical adviser to the Coal Controller of Yorkshire, and was a member of the National Industrial Council for the Electricity Supply Industry. He did a great deal of experimental work on the subject of fuel economy, and as long ago as 1913 designed a generating station in which surplus coke-oven gas was used as fuel. From the same point of view he was also associated with the development of both high and low-temperature coal carbonisation processes, being for a time engineer and manager of the Yorkshire Waste Heat Company, Limited, and consulting engineer to the British Carbide Factories, Limited. In addition to being managing director of the Yorkshire Electric Power Company and Electrical Distribution of Yorkshire, Limited, he was chairman of the West Gloucestershire Power Company and a director of the Mid-Cumberland Electricity Company, of the North Lincolnshire and Howdenshire Electricity Company, and of the Penrith Electric Company. He also took an interest in local government and was chairman of the Bramhope Parish Council.

THE LATE SIR JOHN GILMOUR.

The death of Sir John Gilmour, which occurred on March 30, renders vacant a ministerial post which has been in existence for only a few months. The decision to set up a Ministry of Shipping was taken on September 13 of last year, and Sir John, the first Minister, was appointed shortly after. About the necessity for the formation of such a Ministry in present conditions there was little difference of opinion, but the selection as its head of one who had no experience of shipping, either in an administrative post or as an owner, caused, as we said at the time, a certain amount of astonishment. Sir John, as a one-time director of the Caledonian Railway, had presumably some knowledge of the operation of Clyde steamers, but this would hardly appear likely to constitute him an authority on the shipping industry generally. The Ministry he controlled had been in operation such a relatively short time that no fair measure of his direction of its complicated activities can be taken. Certainly there has been considerable criticism, but not more so than of some other war ministries. Sir John as a former Secretary of State for Scotland, Minister of Agriculture and Fisheries, and Home Secretary, had much accumulated experience of governmental administration, and, working in conjunction with the shipping experts who were appointed to posts under him, might, had fate allowed, have built up a valuable organisation in his new sphere.

Sir John belonged to a family long interested in public affairs. He was born at Montrave in Fifeshire in 1876, and educated at Trinity College, Glenalmond; Edinburgh University; and Trinity College, Cambridge, and, following the traditions of his family, was continually active in the public interest, particularly in Scotland. He was closely associated with agricultural interests and was on the board of the Highland Agricultural Society and a member of the Scottish Agricultural Organisation Society. He served both in the South African War and in the Great War, during which he held the rank of Lieutenant-Colonel. He was Rector of Edinburgh University from 1926 to 1929, and was an LL.D. of Glasgow, Edinburgh and St. Andrews.

THE LATE PROFESSOR S. M. DIXON.

We have received with regret the news of the death of Professor Stephen Mitchell Dixon, which occurred suddenly on March 25 at Nice, whither he had gone to live on his retirement three years ago. Professor Dixon, who was 72 years of age, was a son of Mr. George Dixon, of Dublin, and was one of five brothers, all of whom were university graduates and attained distinction in the academic world. He received his general education at Rathmines School, and afterwards went up to Trinity College, Dublin, passing out with the degree of B.A.I. After serving as assistant moderator in experimental physics, he left the University in 1890 to take up the appointment of assistant engineer to Messrs. Lovatt and Company, and the next two years were occupied on work connected with the King's Cross and Redhill railway tunnels. In 1892, at the early age of 24, he was made Professor of Civil Engineering in the University of New Brunswick, Fredericton, Canada, continuing to occupy this position for ten years, when he was appointed to the University of Dalhousie, New Brunswick, in a similar capacity. In 1905, he returned to the United Kingdom to occupy the Chair of Civil Engineering at the University of Birmingham, and seven years later became Dean of the Faculty of Science at that University. In 1913, however, he left Birmingham and proceeded to London, having been made Professor of Civil Engineering in the Imperial College of Science and Technology, South Kensington. He remained in this capacity until his retirement, at the age of 65, in 1933. For three years prior to his retirement, namely, from 1930 to 1933, he was Dean of the City and Guilds Engineering College, South Kensington.

When the Ministry of Munitions was established during the war of 1914-1918, Professor Dixon was appointed personal assistant to Sir Henry Fowler, Director of Production, at the Ministry. In 1916, however, Professor Dixon relinquished this position, after holding it for some months, and, although 48 years of age, applied for a commission in the Royal Engineers. This was granted, and, in 1917, he joined the British Expeditionary Force in France as a lieutenant, R.E. He was promoted to the rank of captain in 1918, and remained overseas until 1919. Professor Dixon was appointed a member of the Safety in Mines Research Board in 1923 and continued to participate in its activities until 1935. A number of valuable researches on concrete and also on wire ropes were carried out in his laboratories, and under his direction, and for his work in this sphere he was made an O.B.E. on his final retirement in 1937. Professor Dixon, who held the degrees of M.A. and M.Sc., in addition to that of B.A.I., became an associate member of the Institution of Civil Engineers on December 6, 1892, and was transferred to the class of member on March 20, 1906. He was the recipient of a Trevithick Premium and had delivered a Vernon-Harcourt Lecture before the Institution.

THE IRON AND STEEL INSTITUTE.

The 70th annual general meeting of the Iron and Steel Institute will take place at the offices of the Institute, 4, Grosvenor-gardens, London, S.W.1, on Thursday and Friday, May 2 and 3. There will be no annual dinner this year, but, in its stead, a members' luncheon will be held at Grosvenor House, Park-lane, London, W.1, at 1 p.m., on Friday, May 3. The programme of the proceedings, together with a list of papers to be presented, is given below.

Thursday, May 2.—At 10 a.m. Presentation of the annual report of the Council and statement of accounts for 1939. Induction of the newly-elected President, Mr. John Craig, C.B.E., into the chair. Announcement of the election of M. Eugène Schneider, D.Sc., to honorary membership of the Institute. Presentation of the Bessemer Gold Medal to Dr. Andrew McCance. Presentation of the Williams Prize for 1939 jointly to Mr. W. B. Lawrie, for his paper, "The Refining of Metal in the Basic Open-Hearth Furnace," and to Mr. W. T. Wilson, for his paper, "The Rolling of Sections at the Appleby-Frodingham Steel Company, Limited." Announcement concerning the award of the Ablett Prize for 1940. Presidential Address by Mr. Craig. Presentation of two papers for discussion, namely: "Researches into the Structure of Alloys," by Dr. A. J. Bradley, F.R.S., Professor W. L. Bragg, F.R.S., and Dr. C. Sykes; and "Manufacture of Pig Iron in America," by Mr. W. A. Haven.

At 2.30 p.m. Presentation of three papers, namely: "Report on Corrosion Research Work at Cambridge University Interrupted by the Outbreak of War," by Dr. U. R. Evans; "The Damping Capacity of Steel and its Measurement," by Mr. G. P. Contractor and Professor F. C. Thompson; and "The Estimation of Hydrogen in Steel and Other Metals," by Mr. W. C. Newell.

Friday, May 3.—At 10 a.m. Presentation of three papers, namely: "Anti-Piping Compounds and their Influence on Major Segregation in Steel Ingots," by Dr. E. Gregory; "Heat Transfer in the Flow of Gas through the Interstices of a Bed of Solid Particles," by Messrs. O. A. Saunders and H. Ford; and "Method of Sclero-Grating Employed for the Study of Grain Boundaries and of Nitrided Cases: Grain Structures Revealed by Cutting," by Mr. O. W. L. Ljunggren.

Australian-Built Locomotives for N.S.W. Railways.—Five Pacific-type 4-6-2 locomotives are being built for the New South Wales Railways by the Clyde Engineering Company, Granville N.S.W. *The Commonwealth Engineer* states that each locomotive, which will be partially streamlined, will develop a tractive effort of 36,500 lb., steam at 245 lb. per square inch pressure being delivered to the cylinders, which have a diameter of 26 in. and a piston stroke of 21 ft. 6 in. The driving wheels are 69 in. in diameter, and will be fitted with roller bearings. The total wheel base of each locomotive and tender will be approximately 65 ft. 10 in., and the approximate length over the buffers will be 76 ft. 5 in. The estimated total weight of engine and tender will be 186 tons.

NOTES ON NEW BOOKS.

Practical Microscopical Metallography. By DR. RICHARD HENRY GREAVES and HAROLD WRIGHTON, B.Met. Third edition. London: Chapman and Hall, Limited. [Price 18*s.* net.]

THE study of the metals and alloys with the aid of the microscope has resulted in the development of a most fascinating technique, by which remarkable results have been achieved. The extent to which microscopical metallography has advanced from the laboratory stage to application in industrial processes is well portrayed in this volume, although it is necessary to guard against a too liberal interpretation of the results obtained by means of microscopical methods before further advances in knowledge have been made. The first edition of this work appeared in 1933; it has now been considerably expanded to cover many new fields and amply demonstrates that the microscope has become an instrument for the determination of definite structural properties in metals and is not merely a magnifying instrument. The sections dealing with the structure of alloys have been rewritten, to bring them more into accord with the results of recent researches in the subject, and some additional well-prepared microphotographs have been introduced which illustrate the various structures in the metals and alloys, and in certain other commercial materials. The authors emphasise the importance of the structure of metals in many industrial fields, and valuable information is given relating to technical developments in the study of illuminants and objectives, as applied in microscopical metallography.

Theory of Machines. By L. TOFT, M.Sc., and A. J. T. KERSEY, A.R.C.S. Fourth edition. London: Sir Isaac Pitman and Sons, Limited. [Price 12*s.* 6*d.* net.]

THE publication of new editions of technical books is usually an indication of merit, and also gives the author the opportunity of effecting improvements. This is especially the case in the present instance, and the authors deserve a note of thanks for their careful revision of the text in order to meet the requirements of the latest syllabus of the University of London. The requisite standard has been attained by extending the previous study of several problems, among which may be mentioned the theory of dynamically-equivalent systems and of belt drives. Substantial additions have been made to the discussion on oscillations in general, and the vibration of rotating shafts in particular, with the result that the fourteen chapters together constitute an excellent introduction to the dynamics of machinery. At the present time there must be many young engineers who are unable to attend college courses and who feel the need of guidance along the path leading to a university degree or to the associate-membership of the senior institutions. Having regard to these circumstances, and to the numerous ramifications of the theory of machines, it is pertinent to remark that the book can be followed by the serious student without the aid of an instructor, the descriptive matter and the proofs of the chief theorems and formulæ being well illustrated by worked examples and nearly 400 exercises with answers. Hence the reader who is not especially proficient in mathematics may obtain a clear idea of what is required in this branch of mechanical science.

A.S.E.E. Guide to the Electrical Regulations. London: The Association of Supervising Electrical Engineers. [Price 1*s.* 6*d.* (paper covers), or 2*s.* (cloth), including postage.]

THE Regulations for the Electrical Equipment of Buildings which have been issued for many years by the Institution of Electrical Engineers and have now reached their eleventh edition, contain a great deal of information regarding the design of equipment and the method of its installation, but much of the wording is of that involved character which seems to be inseparable from any document of a semi-legal character. Some time ago, therefore, the Association of Supervising Electrical Engineers prepared a Guide to the ninth edition of the Regulations, the idea being to provide in a booklet of handy pocket size all those rules which are of direct interest to "the man on the job," and to present them in a manner that will be less confusing to the ordinary electrician than the original document. The latest edition of the Guide, which relates to the eleventh edition of the Regulations, has now been published. The work has been performed with the approval of the Institution, the only stipulation being that where the wording was altered the changes were to be shown in special type, and were to be made on the sole responsibility of the Association of Supervising Electrical Engineers. As will be appreciated, it has not always been easy to do this, but as far as can be seen the revision has been carried out with discretion and without loss of clarity. Some definitions have been omitted as being common knowledge. On the other hand, numerous diagrams, elucidating various points, have been specially drawn for the Guide. As an example of the simplifications that have been made, "ambient" has been altered to "surrounding," "curtilage" to "boundaries," and "eutectic" to "easily fusible." Cross-references from one regulation to another, generally speaking, have been omitted and there has been a good deal of condensation. The Guide is intended to be explanatory and not critical, and no attempt has been made to introduce anything which alters the sense of the original.

Metal Working Tools. By PERCIVAL MARSHALL. *Micrometers.* By ALFRED W. MARSHALL and GEORGE GENTRY. *Standard Screw Threads and Twist Drills.* By GEORGE GENTRY. London: Percival Marshall and Company, Limited. [Price 1*s.* 6*d.* each.]

AT the present time, large numbers of workers are entering the engineering industry as dilutees without any previous knowledge of the tools, processes, or materials in general use, and many of these workers will desire to increase their efficiency by learning something of the work going on around them but outside their own activities. For such a purpose, the three handbooks recently published by Messrs. Percival Marshall can be recommended. None of the three books is new, but all have been revised and new matter and illustrations added. Of the three, that entitled *Metal Working Tools* gives a simple description of the hand tools in common use in the workshop, including appliances for measuring and marking off, with advice on their correct use and maintenance. More detailed information on measuring instruments is given in the book on "Micrometers," which also includes descriptions of slide gauges and calipers, while the third book, entitled *Standard Screw Threads and Twist Drills*, deals with all the screw threads in general use. In the chapter devoted to twist drills, a very complete table is included, giving the decimal size corresponding to the number or the diameter of the drill in fractions of an inch.

Engineering Design. By J. E. TAYLOR and J. S. WRIGLEY. London: Sir Isaac Pitman and Sons, Limited. [Price 10*s.* 6*d.*]

ALTHOUGH primarily intended as a text-book for students at universities and technical schools covering the syllabuses of the B.Sc. (Eng.) and equivalent examinations, this book should be of value to many designers and draughtsmen engaged in practical work. It is an attempt to connect up theoretical work in strength of materials and allied subjects with actual design of machine parts, and throughout the book emphasis has been laid on the importance of applying fundamental principles. No attempt is made to derive the formulæ used, but the meaning of every symbol employed is carefully specified, and the derivation of the formulæ themselves can be readily determined from almost any text-book on mechanics or the theory of structures. The value of the book to the draughtsman lies in the fact that it enables him to make any calculations essential to his work on a rational basis instead of relying on pocket-book formulæ which not infrequently land him in difficulties. To increase the value of the work to engineers generally, as distinct from university or college students, frequent references have been made to specialised works and to recent research and practice. The subject matter is dealt with in two sections, the first dealing with general principles and the second consisting of complete examples of design. The section dealing with general principles includes the treatment of stresses and strains, fatigue and creep of metals, and so on, while the examples selected for the second section are mainly such as are likely to be met with in general practice, such as couplings, pulleys, shafting, clutches, and brackets.

Design and Construction of Air-Raid Shelters. By DONOVAN H. LEE, M.Inst.C.E. London: Concrete Publications, Limited. [Price 8*s.* 6*d.*]

ALTHOUGH it is to be hoped that the greater number of air-raid shelters necessary for the protection of the public in the case of extensive raids have now been provided, many of the earlier shelters built were hastily improvised, and are now showing signs of deterioration. They, therefore, require reconstruction, and apart from this, the construction of new factories, with the concomitant movements of considerable numbers of workers and their families, involves the extensive construction of shelters in fresh areas. It is highly desirable in such cases that designers should have conveniently available the accumulated experience of those who have been associated with shelter construction in this and other countries, so that the earlier mistakes may be avoided. An outstanding example of such a mistake was the provision of numerous Anderson shelters for private dwellings without means to prevent flooding, or to remove the water where flooding was unavoidable. The *Design and Construction of Air-Raid Shelters in Accordance with the Civil Defence Act, 1939, and for Unspecified Areas, and Other Purposes*, which we believe to be the only book published giving complete designs in conformity with the Home Office Revised Code, is, therefore, likely to be in considerable demand. The provision of shelters which would give complete immunity from the effects of aerial bombs has, in practice, been found to be prohibitive in cost, and, as stated in the preface, the accepted policy now is to provide shelter against the generally-known effects of blast, splinters, incendiary bombs, concussion, and possibly small high-explosive bombs, although much less is known about the effects of concussion than of other possible causes of damage. On this account, it appears to be open to question whether the type of small shelter wholly or mainly above ground level is altogether desirable. Complete dimensioned designs are given in the book for 12 types of shelters for 50 persons in concrete, brick, steel and timber with earth cover, and there are six designs in concrete and brick for warden's posts and other smaller shelters for five to 24 persons. In each case a full list of quantities is given, so that the relative cost of the different types can be readily ascertained in any district according to current prices and the availability of different materials. The designs include splinter-proof and blast-proof surface, partly sunk, and fully-sunk shelters, so that a design can be selected to suit any particular site.

Engineering Reorganisation. By JAMES J. GILLESPIE. London: Sir Isaac Pitman and Sons, Limited. [Price 12*s.* 6*d.*]

IN ENGINEERING, vol. 143, page 23, *et seq.* (1937), will be found a series of articles by Mr. J. J. Gillespie on "Engineering Works Reorganisation." These articles have now been very considerably amplified by the author, and reprinted in book form under the title of *Engineering Reorganisation*. Mr. Gillespie is a well-known authority on this subject, and, in a foreword to the book, Mr. David Brown, managing director of Messrs. David Brown and Sons (Hudd), Limited pays a warm tribute to the attitude which the author has to his work. Briefly, this viewpoint consists in stressing not only the value of personal worth in organisation, but the value of personal worth in a group setting. This is clearly brought out in the section devoted to Management Personal Analysis, where the author remarks that as his experience increases, he pays less and less attention to method and system and more to people's reactions and what they are prepared to be and do. Few will be found to dispute the soundness of this, as everyone with experience of works organisation realises the danger, inevitable in the modern tendency towards larger groupings, of losing sight of the human element and ruling by regulation. While it is impossible in a short notice to give an adequate idea of the contents of a book of this type, it may be mentioned that all the more important aspects of works organisation are dealt with. The author is provocative throughout, and is not sparing in criticism of a number of established conventions, a point of view that cannot be other than stimulating to the thoughtful reader. It may be stated in conclusion that while continuous or mass production is outside the scope of the book, there can be few organisations in which greater effectiveness could not be secured by a careful study of its pages.

MINERAL PRODUCTION IN QUEBEC.—During January, 1940, 26,851 tons of asbestos, 83,505 oz. of gold and 96,159 oz. of silver were produced in the Province of Quebec, against 31,930 tons, 81,804 oz. and 100,376 oz., respectively, in the previous month.

EXHIBITION OF MUNITION SAMPLES.—The Ministry of Supply informs us that the Exhibition of Munition Samples, London and South-Eastern Area, has been moved from Savoy Hill House to 111, Penfold-street, Paddington, N.W.8, and was opened there on April 1. Applications for permits to view the exhibition should be made to the Area Officer, London and South Eastern Area, Ministry of Supply, whose present address is, Savoy Hill House, London, W.C.2. (Telephone: TEMple Bar 1221, Extension 128.)

DEMURRAGE CHARGES ON PARCELS FOR SOUTH AFRICA.—Members of the Cape Town Chamber of Commerce have called attention to the difficulty experienced through the receipt of invoices from overseas too late to allow parcels to be cleared before demurrage becomes due. In reply to representations on the subject, the Postmaster-General has pointed out that the deposit system is available, and that another way of overcoming the difficulty is for importers to request their shippers to arrange for a certified copy of the invoice to be enclosed in the parcel to which it relates, the cover being endorsed accordingly.

LABOUR NOTES.

Writing in the March issue of the *Trade Report* of the United Patternmakers' Association, Mr. Findlay, the general secretary of the organisation, states that in February there was a considerable increase in the number of members on sick benefit. In December, the total was 238, and in January 349. In February, it was 594. The unemployment figure remained stable—64 as compared with 63 in January—and the number of superannuated members was 675, as compared with 678 in January. The total number of members is 12,241.

Nearly 200 resolutions have been sent up for discussion at the Labour Party conference, which is to be held at Bournemouth at Whitsuntide. Several local Labour parties, and the Railway Clerks' Association, have put forward resolutions demanding a graduated levy on wealth to finance the war, and another series of resolutions calls for the preservation of the wage-earners' standard of living. An increase of allowances to dependents of men in the armed forces is another subject to be raised. Sixteen resolutions press for the adoption of Labour's plan for increased old-age pensions and protest against a household means test. The Amalgamated Engineering Union has sent in a resolution demanding more adequate medical treatment under the National Health Insurance scheme, and other resolutions claim increased unemployment benefit and allowances. A resolution on the nationalisation of all public transport is sponsored by the Railway Clerks' Association.

The War Office states that a leaflet issued by the Ministry of Labour and National Service dealing with the arrangements which, in very exceptional circumstances, permit (*a*) the deferment of the calling-up of men under the National Service (Armed Forces) Act and (*b*) the release of men from the Forces, covers the several steps taken since the beginning of the war to release individual men on account of their industrial skill. The leaflet does not, however, make it plain that to a substantial extent the release of such men has already been completed. In particular, the release of several hundred men called up under the Military Training Act who belonged to occupations reserved at the age of 18 in the Schedule of Reserved Occupations issued in September, 1939, was completed during the first two months of the war, and the comb-out of the Territorial Army Field Force, involving the release of several thousand men, has been completed recently. Commanding officers of units in the Territorial Field Army cannot now answer inquiries why individual men have not been released.

The comb-out of anti-aircraft and coast-defence units and home-defence battalions is still proceeding, and eligible men are released automatically. Commanding officers can answer inquiries about the eligibility of individual men for release under this comb-out. Only men who were in the Territorial Army before the war and who belonged to industrial occupations, reserved at the ages of 18, 21, or 23 in the Schedule of Reserved Occupations published in September, 1939, are, in general, available for release from these units and battalions provided (*a*) that they are at, or above, the reservation age for their particular occupation; (*b*) that they are not officers, warrant officers, or non-commissioned officers; and (*c*) that there is no Army trade corresponding to their civil occupation.

Writing on Friday last week, the Paris correspondent of *The Times* said that the Ministry of Labour had announced that within the next few days a decree would be published making compulsory the employment of a certain proportion of women—100 per cent. in some cases—in a number of industries. The announcement revealed, the correspondent went on to say, that, in February alone, 170,000 women were taken on in war industries, including textiles, and pointed out that in the establishments directly under the control of the Ministry of Armaments 29 per cent. of the workers were women. The aircraft industry employed many women. Under the new recruiting regulations, it was added, priority will be given to women without resources, particularly wives of soldiers not in receipt of separation allowances and war widows and women without families who have been brought up in State institutions. The public are reminded that if voluntary workers do not present themselves in sufficient numbers a compulsory system will be introduced.

In the course of his presidential address to the annual conference of the Trade Union Unemployment Insurance Association in London last week, Mr. George Hicks, M.P., said that plans ought to be made now to deal with the conditions which will arise after the war. Just as preparations for war were made in time of peace, so, he went on to say, should preparations for peace be made in time of war. When the war ended those engaged on war work would have no such employment, and the bulk of the men in the fighting Services would be thrust into the army of the unemployed. No one could regard without fear and shuddering the economic dislocation and the plight of millions in such a situation. He therefore urged that plans should be made now for dealing with post-war conditions.

It might be thought, Mr. Hicks said, that the present time, on account of the upheavals, stresses and difficulties of the war, is not the most opportune moment for raising the issue of the right to work. In his opinion, no time was more propitious than the present. It was the most disgraceful and wasteful thing imaginable that there should be a million and a half unemployed at a time when the nation is most desperately in need of their services. If ever the seal of mismanagement and inefficiency was set upon those responsible for the ordering and conduct of society, it was set upon our ruling class now by the existence of our great army of unemployed. Another reason for raising the issue, was, Mr. Hicks said, that, with so much talk of equality of sacrifice, there should be equal distribution of essential supplies. There must be no semi-starvation of some people, he declared, while others had a surplus of food.

Returns received by the United States Bureau of Labour Statistics from employers, covering over one-half of the aggregate number of wage-earners in manufacturing industries, indicate that the workpeople employed in the middle of December, 1939, showed an increase of 0·2 per cent., as compared with the previous month. Aggregate weekly earnings in the establishments covered rose during the same period by 2·1 per cent. If the average monthly index of employment in manufacturing industries for the three years 1923-1925 be taken as 100, the corresponding index for December, 1939, was 104·0, as compared with 103·8 for the previous month, and 94·0 for December, 1938.

At the end of December, 1939, 5,729,484 applications for employment were registered at the Public Employment Exchanges, an increase of 1·8 per cent. as compared with the previous month, but a decrease of 20·6 per cent. as compared with December, 1938. According to the estimates of the American Federation of Labour, the total number of unemployed persons in the United States in December, 1939, was 9,379,000, as compared with 9,369,000 in November, 1939, and 10,335,000 in December, 1938. The National Industrial Conference Board assesses the total number of unemployed persons in December, 1939, at 8,428,000, as compared with 8,335,000 in November, 1939, and 9,304,000 in December, 1938.

Under the title of "Actuarial Technique and Financial Organisation of Social Insurance," the International Labour Office at Geneva has published a study by Dr. Lucien Féraud on the actuarial technique and financial organisation of compulsory (contributory) invalidity, old-age and widows' and orphans' insurance schemes. The method followed is that of a series of monographs on the schemes in force in certain countries. The schemes chosen are those of Belgium, Czechoslovakia, France, Germany, Great Britain and Italy. Each is studied throughout its history, and forms the subject of a separate and complete monograph. A general introduction brings out the essential financial and technical features of the schemes analysed and facilitates a certain amount of comparison. The material for each of the monographs is mainly drawn from the actuarial studies to which the preparation, administration and reform of the insurance legislation in question gave rise. The more important numerical data (mortality, invalidity, annuity tables, etc.) are given, as well as bibliographies.

A general statement on labour policy has been issued by the Congress of American Industry, which was held recently in New York under the auspices of the National Association of Manufacturers. On the subject of "reasonable hours of employment," it is stated that at any given stage of technological progress, the level of the nation's productivity is dependent on the cheapness of the hours of work within the limits of human efficiency which labour performs. In recent years, there has been a tendency to move more rapidly in the direction of decreased working hours than was justified by the increase in productive efficiency. In addition to the problems of the long-term adjustment of working hours to productive efficiency, there are also to be considered, the statement continues, the problems connected with the spreading of available work in periods of depression and widespread unemployment. Under such circumstances, it is pointed out that it may be necessary to resort to spreading the available work among those who can be employed productively.

But, the statement proceeds, it is important that any such programme should not be carried to an extent which, by unduly raising costs, will undermine the earning capacity of labour and the purchasing power of all. The principle of "sharing the work" should be applied only as a measure of expediency, with due consideration, on the one hand, to conditions known to exist specifically in the community where each plant is operating, including the prospective burden of relief costs and the desirability of maintaining the working habits and skill of employees; and, on the other hand, to the adverse effects inevitably exerted upon the national economy. In meeting both the long-term and short-time problems, the statement concludes, advantage should always be taken of suitable opportunities to extend reasonable hours of employment, so that within the limitations of economical cost of production, those employed may be able to enjoy high income and purchasing power.

Over 1,400 industrial units in New York State, employing more than 600,000 workers, have agreed to a "hiring and firing" plan designed to assure a certain proportion of jobs to middle-aged workers. The "Rochester formula," as the plan is known, is to maintain between older and younger workers in any industrial establishment a balance which would closely resemble the age distribution of the community's working population. Mr. Wadsworth, chairman of the States' joint legislative committee to investigate discrimination against middle-aged workers in employment policies, stated that the committee and the Rochester industrialists who first agreed to the plan have received numerous inquiries from all over the country, and that several other States (either through legislators or departmental heads) have expressed a desire to try the plan. A further step to aid older workers has been taken in a recent union agreement. The contract signed between representatives of the New York Electrical Contractors' Association and a New York branch of the International Brotherhood of Electrical Workers makes mandatory the employment of one union member over 55 years of age in every group of ten workers employed.

According to returns received by the National Industrial Conference Board and the United States Chamber of Commerce, there is a shortage of some kinds of skilled labour in several parts of America. The metal-working trades are stated to be chiefly affected. The Congress of Industrial Organisations, on the other hand, has issued a pamphlet in which it is suggested that the shortages of labour which have been found are merely wishful thinking on the part of those "who wish to believe that the nation does not have to provide for its unemployed." It declares that employers' complaints of the lack of skilled labour are usually derived from the fact that there may be no unemployed men of highly-specialised skill standing at the doors of their plants. The United States Employment Service files show many hundreds of thousands of skilled mechanics unemployed, the pamphlet adds, and C.I.O. records show highly-skilled men working on semi-skilled jobs because no skilled work is available. It also points out that a Government committee which recently examined the availability of workers for the aircraft industry found that there were many thousands more skilled mechanics available than the industry was expected to need for some time.

At a recent meeting of the Central Committee of the International Metal Workers' Federation, a resolution was passed reminding metal workers that trade unionism remained under all circumstances, even during the war, an indispensable means of defence for the working class, and called upon them to remain true to their organisations and affiliated to the International Metal Workers' Federation.

It is reported that technicians are urgently required for the army in South Africa, on account of the great expansion of the Union's defence forces. A training scheme is therefore being organised under which technical schools are to be established in a number of different centres. These schools include an air mechanics' school, an artillery school, an armourers' school, a motor-transport mechanics' school, a signalling school and a school of field engineering. Training will be given for work as armourers, blacksmiths, carpenters, coppersmiths, draughtsmen, electricians, farriers, fitters, instrument repairers, mechanics, sheet-metal workers, turners and machinists, tinsmiths, welders and wireless mechanics.

ELECTRIC CABLES AND FIRE RISKS.

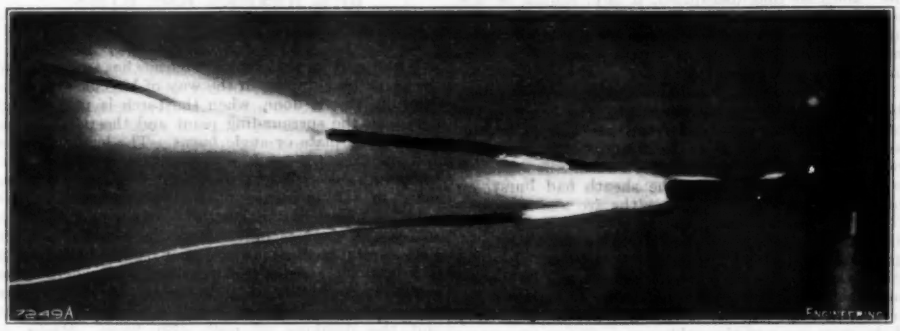


FIG. 9. FLAME TESTS ON VULCANISED-RUBBER CABLES.

ELECTRIC CABLES AND FIRE RISKS.

As a result of various inquiries, it has been established that the fire risk due to faulty electric cables is exceedingly small, though precautions must be taken to prevent damage due to extraneous fires. This problem is considered in a paper on "Electric Cables and Fire Risks," which was read by Mr. S. W. Melsom before the Transmission Section of the Institution of Electrical Engineers on Wednesday, March 13. Dealing first with the fireproofing of main cables in power stations, the author pointed out that where these emerge from the floor they can be protected by moulded asbestos, which has sufficient heat resistance and a thermal resistivity so low as not unduly to decrease the current rating. It is, however, somewhat alkaline, so that the lead sheath should be protected with bitumenised tape to prevent corrosion. On new installations, a cable with two layers of hessian tape impregnated with fire-resisting compound beneath the wire armouring can be used. For existing installations, asbestos tape can be applied after stripping the ordinary wrappings.

The fire-resisting or flame-retarding properties of the cables with standard vulcanised-rubber dielectric, which are so widely used in buildings, ships and mines, depend upon the outer protection which, in the small sizes, usually takes the form of a single or double braiding of cotton, wool or asbestos treated with some form of fire-resisting compound. While such cables represent the best that can be done with rubber dielectric they are not best from the fire-resisting point of view. To obtain the best results it is necessary to have a relatively thick outer protection, which increases the overall diameter and may introduce installation difficulties and retard production. A cable with a dielectric having the properties associated with rubber which also possessed inherent fire-resistance would, therefore, represent a definite step forward. Cables having mineral dielectrics, such as asbestos or magnesia, have been available for some time, but, although they have satisfactory fire-resisting properties, they require special end-sealing to protect them from moisture. In addition, they tend to be rigid, which renders installation difficult. Quite a fair degree of success has been achieved in producing fire-resisting or self-extinguishing rubber compounds. The addition of the necessary materials to the rubber, however, modifies its desirable properties. A successful self-extinguishing dielectric should be a material which, in the raw state, has both rubber-like and fire-resisting properties. Such a material can be produced by the polymerisation of 2-chlorobutadiene, which belongs to the same general chemical group as rubber and in the raw state has very similar physical properties. In that state, however, it is unsuitable for the manufacture of cables and has to be converted into a suitable "mix." Exhaustive tests have shown that this synthetic material is more resistant than rubber to heat, oxygen, light and oil, and experience over 5 or 6 years indicates that a satisfactory life may be anticipated from a cable in which it is used. Its electrical properties are interesting, but in one respect unfortunate for, while the breakdown value is comparable with that of rubber, the insulation resistance is so low that the material would be unacceptable if used alone as a dielectric for general wiring work. As a result of experiments, however, it has been possible to obtain a dielectric which, while self-extinguishing to a very high degree, also complies with all recognised electrical pressure tests for rubber cables and has an insulation resistance which, although somewhat lower than that normally associated with vulcanised rubber, is ample for all wiring purposes. It has, further, been found possible to obtain these properties with the new dielectric applied to the same radial thickness as the standard vulcanised rubber.

The outstanding properties of the new fire-resisting dielectric in neither spreading a fire nor initiating it, can be demonstrated by laboratory tests. An example of a test is shown in Fig. 9, above. In this, a sample of the new fire-resisting insulated cable was subjected to an external fire. Not only was the fire-resisting dielectric difficult to ignite, but all action ceased in about 60 seconds and the core was impervious to continued application of the flame, only that part in the immediate vicinity of the external flame being affected. Similar results are obtained if an internal arc is caused to occur.

As the dielectric is an organic material, the portion in the immediate vicinity of the arc is, of course, destroyed by the intense heat, but when the arc is extinguished the dielectric is also self-extinguished so that the cable will not convey flames to another part of the installation. Under the same conditions, a standard rubber dielectric will continue to burn. Though an outer covering of braid and fire-resisting compound is not necessary from the fire-resisting standard point, it is applied to afford some mechanical protection during installation or to act as a "key" for paint.

It has been found that a cable made with fire-resisting dielectric and a single cotton braid treated with fire-resisting compound, has better fire-resisting properties than a cable made with standard rubber dielectric and two braids, each heated with fire-resisting compound. The fire-resisting cable is also smaller in diameter and can be manufactured at a higher rate of production. The cable is just as flexible as those with standard rubber insulation and requires no more protection at the ends. So far, development has been restricted to the sizes and types of cable normally used in ordinary wiring work, *i.e.*, braided and compounded and metal sheathed. It is, however, proceeding on other types.

Fires which have occurred in coal mines during recent years have raised the question as to how far electrical cables have been the cause of initiating them or conveying them from one place to another. Some time ago, H.M. Electrical Inspector of Mines inquired whether cable makers would be willing to carry out experiments with a view to obtaining data which would answer certain specific questions, and the following is an account of the work which was carried out as a result. The most important feature of this co-operation has been the correlation of the methods of test with the conditions in a coal mine, the type of fire which occurs there, and the mechanical usage to which cables are subjected as part of the normal working.

Cables used for permanent installation in shafts and in-byes normally have a single wire armouring for external mechanical protection. The armouring generally has a further textile covering thoroughly impregnated with a pitch type of compound to give the maximum protection against corrosion. The first question that arose was whether the external wrapping could be set on fire and under what conditions, and whether, if it could, to what extent it would be likely to convey flame. The cables used for this section of the work consisted of 0·06 sq. in. standard rubber-insulated single-wire armoured cable, and paper-insulated lead-covered cable of the same conductor size but lead-sheathed and single-wire armoured. The testing procedure consisted in laying 1-yard lengths of the cable horizontally about 1 ft. above a laboratory bench and subjecting them to the action of three Bunsen burners (adjusted so as to melt a piece of 0·028-in. copper wire in 5 seconds) spaced equally round the cable at one place. There was no sign of ignition for about 15 seconds, after which the cable began to drop burning compound, which was self-extinguished almost immediately on reaching the bench. Fig. 1, page 360, shows a typical test 30 seconds after commencement. The compound is reasonably well alight. In several instances the cable was removed from the burners when in this condition in order to ascertain whether the wrappings would continue to burn, but in every case they were self-extinguished in about 1 minute, and there was no tendency for the flame to travel along the cable. In other tests the burners were left in position round the cable and under these conditions the flame spread for a short distance on each side of the burners. All samples were, however, extinguished in about 6 minutes to 8 minutes, and a total length of only some 7 in. to 8 in. was affected.

In a typical test 10 minutes after commencement ignition was completed and the cable was affected for only some 3 in. to 4 in. on each side of the burners. In other experiments similar tests were applied to cables in which the wrappings were previously cut about with a knife so as to expose free ends with the object of simulating the wrappings when in a frayed condition. With a reasonable degree of fraying the behaviour of the cable was the same as that of an unfrayed sample, and it was not until the wrappings had been badly mutilated that they could be made to spread flame. Even under these conditions the rate of spread was only about 1 ft. in 3 minutes, and burning was restricted to the cut edges of the wrappings. In another series of tests, the cable was tested in a vertical position. Two burners were applied for 30-second periods, bringing the total time up to 5 minutes. Under these conditions, the wrapping treated with standard petroleum pitch compounds were self-extinguishing without appreciable spread of flame. As about 15 seconds was necessary to ignite the compound on the wrappings of a standard cable, such wrapping would not become ignited by a transient flame, such as an explosion of fire-damp. Relatively prolonged application of external flame which implies an already existing severe fire is, indeed, necessary to ignite the wrapping, and if the source is local, the cable will not in general convey the flame away. As regards damage to the cables themselves, Fig. 3, page 360, shows a typical rubber cable which has been subjected to three burners for 10 minutes, followed by the removal of the outer wrappings and armouring wires. It will be noted that the compound on the hessian bedding has been melted away for some 3 in. or 4 in. on each side of the point of application of the flame, but beyond this nothing has happened. Fig. 4 shows the same cable after the removal of the textile wrappings over the tough-rubber sheath. The latter shows surface charring just at the point of application of the burners, but the cable is otherwise unaffected. Figs. 5 and 6, page 360, show corresponding photographs of a lead-sheathed paper-insulated cable. After removal of the armouring the hessian bedding over the lead was burnt away in the vicinity of the flame and it appeared that the lead had also been melted. Fig. 6, which shows the cable after the removal of the bedding, confirms this, as the lead is melted away locally. Further examination showed that the belt papers were charred, but the actual core insulating papers were unaffected. Similar tests were applied to rubber cables of standard construction, except that the pitch type of compound was replaced by the fire-resisting compound. Fig. 2, page 360, shows such a cable 30 seconds after the application of the burners. It will be seen that there is complete absence of burning compound and even continued application failed to ignite the wrappings. The use of these fire-resisting compounds would, however, render the armouring wires more liable to corrosion. Generally, the results show the extraordinary fire-protective qualities of the amouring wires. Not only are the exterior wrappings and their impregnating compound rendered fire-resisting to a high degree, but the inside of the cable is almost completely protected.

The next question was whether a core-to-core arc, which might arise as a result of mechanical damage to the cable, would set the latter on fire and thus initiate a large fire. The cables for this part of the investigation consisted of 0·1 sq. in. three-core single-wire, armoured, rubber-insulated, impregnated paper-insulated and vulcanised, bitumen-insulated cables, with standard petroleum pitch finish. Artificial short-circuits were made by driving 0·064 in. copper wires through two of the three cores prior to the completion of the cable. To prevent vapours being forced out at the end of the cable as the result of the arc, the test pieces were made 10 ft. to 12 ft. long, with the artificial short-circuit in the middle. For the actual test, the pieces of cable were laid on a concrete floor and the two short-circuited conductors were connected to a 600-volt supply from a 250-kVA single-phase, 50-cycle alternator, giving a short-circuit current of between 1,200 amperes and 2,000 amperes. Under the worst conditions the short-circuit caused a relatively violent explosion, burst the cable, burnt away the conductor for 2 in. to 3 in. and ignited the outer wrappings. The fires were self-extinguished, however, in from 2 minutes to 15 minutes and the burning did not spread away from the immediate neighbourhood of the fault. Though the arc caused severe local

burning of the dielectric, the latter was not further ignited by the burning of the wrappings.

Similar questions to those just discussed naturally arise in connection with flexible trailing and drill cables, which have an unprotected rubber sheath and are more liable to mechanical damage which might give rise to internal arcing. The results of a second series of tests, however, indicate that the likelihood of a standard trailing cable becoming ignited by a transient flame is very remote and even if the sheathing did become ignited the flame could be extinguished quite easily without having spread. The results further suggest that the external flame conditions necessary to get the cable really well alight are such as would arise only if there were already a severe conflagration going on in the mine, in which case any secondary effect resulting from the cable would be relatively unimportant. Generally, the results indicated that standard rubber trailing cables have a greater degree of fire resistance than might have been expected, and it is evident that from the standpoint of resisting an external source of ignition the present type of cable is satisfactory. Tests were also made to determine the effect of a core-to-core arc, lengths of 0·0225 sq. in. four-core unscreened trailing cable being used for this purpose. For the first test a sample about 5 ft. long was crushed between steel plates about 6 in. square until core-to-core failure was known to have occurred. This required a load of some 10 tons and the cable was crushed almost flat. The cable was then connected to a 600-volt alternating-current supply and a load of 1 cwt. dropped on to the damaged portion so as to produce a short-circuit. The arc burnt away the conductor for 2 in. to 3 in. and burst the sheathing. The cable caught alight very feebly, but was self-extinguished in less than 30 seconds. In another experiment, a sample, which had been previously damaged by being crushed, was connected to a 50-volt direct-current generator and hit violently with a sledge hammer, the cable itself lying on a steel plate. After considerable maltreatment, resulting in complete bursting of the sheath and severe damage to the conductor, it was possible, by agitating the cable, to produce core-to-core arcing and by maintaining this for about 30 seconds to get the cable alight to such a degree that it would continue to burn. The experiments showed, however, that extraordinarily severe mechanical damage was necessary to cause the arc to be started.

Similar tests were carried out on lengths of cable made with standard rubber cores and a fire-resisting sheathing. In this case, the cable burnt while the arc was maintained, but unlike the standard type, was self-extinguished when the arc was broken without the fire spreading away from the immediate vicinity, although the cable had been so badly damaged as to give free access to the cores. The use of a fire-resisting sheathing would, therefore, be one way of localising a fire which might be initiated as the result of an internal arc. In this connection, it may be noted that considerable attention has been given to the production of cables having the properties associated with rubber, but with improved fire resistance, and many types of rubber and rubber-like compounds have been produced experimentally, both for use as dielectrics and sheathing.

As a result, as mentioned above, a special type of dielectric has been developed which is already in use for certain types of cables. The major difficulty, so far as sheathings are concerned, is that hitherto fire-resisting properties have been obtained at the expense of such properties as tensile strength and resistance to tear. It is now possible, however, to produce fire-resisting sheathings which, while not possessing such high tensile strength or tear resistance as the standard-resilient tough-rubber sheathing, may have sufficiently good mechanical properties to allow of its use for trailing cables in mines.

These results, showing as they do the great difficulty in maltreating a cable so badly as to produce an internal arc and the comparative ease with with the flame resulting from such an arc is extinguished, indicate clearly that the existing standard cables are adequate for their service. Consideration of the extent to which the normal overload protection used in mines is suitable for clearing faults of this kind led to a series of experiments under conditions which can hardly occur in practice. Four sets of samples were made up of standard vulcanised rubber dielectric with standard and fire-resisting sheaths, respectively, and of fire-resisting dielectric with standard and fire-resisting sheaths, respectively. The conductor was 0·225 sq. in. with a dielectric 0·062 in. and a sheath 0·15 in. thick. Weak places were spaced every 2 ft. and as the conductor was semi-broken before the dielectric was applied, complete breaks could be made by moving the cable without in any way affecting the dielectric or sheathing. This arrangement also allowed the broken ends of the conductor to be pressed together and withdrawn to start and continue the arc. In fact, by the use of the comparatively simple apparatus shown in Figs. 7 and 8, page 360, the position of the cores could be varied at will. In order to obtain the most severe result, the supply was from a large 500-volt direct-current generator, the current being intentionally maintained at low values so that disruption, if any, should be due to a continuous arc rather than a short duration arc of high current. The actual currents applied to the cable were, therefore, 4 amperes, 10·5 amperes and 20 amperes, respectively.

In every test at 10·5 amperes and above and in half the tests at 4 amperes the sheathing was burst by the internal pressure developed from the thermal decomposition of the dielectric. At 20 amperes the bursting was relatively violent and in a few cases was sufficient to quench the arc. After the sheath had burst, no further action took place unless the arc was restarted. This effect seemed more likely to occur with the higher currents. In many cases the standard sheath became ignited within a few seconds of the bursting. In most other cases the dielectric was converted into a carbonised and conducting red hot mass. In some instances this became self-ignited, or, if this did not happen, very slight movement of the cable was sufficient to restart the arc. A standard rubber sheath, whether used in conjunction with standardised vulcanised rubber or fire-resisting dielectric, can be made to continue burning relatively easily, but cables using a fire-resisting sheath are superior from the standpoint of the cable becoming ignited as they are self-extinguished after the arc ceases. All four types of cable allow flame from the arc to reach the atmosphere and thus could cause a fire in a gassy or fiery mine. The fact that under some conditions the dielectric is converted into a red hot conducting mass which sometimes becomes the immediate cause of the cable igniting, suggests that the use of a conducting screen connected to a quick-operating earth-leakage device will prevent either open sparking or ignition of the cable. To test this idea, a pre-formed wire braid was slipped over the cable and connected to an earth-leakage trip. A 4-ampere arc was struck between the broken conductor and the ammeter showed that this current was maintained for one hour, presumably owing to the formation of a carbonised mass. The current was then increased to 8 amperes for 1½ hours, during which time repeated attempts were made to produce some fault by hitting the sample with a hammer. There was no visible result, and the earth-leakage trip did not operate. On opening up the cable, it was found that the whole of the dielectric was carbonised in the immediate vicinity of the arc and the sheathing was also carbonised for the greater part of its thickness. There was, however, still about $\frac{1}{16}$ in. of sound sheath immediately beneath the screen. In other experiments carried out, both at 10·5 amperes and 20 amperes, the sheath beneath the wire braid screen did not burst, but gases were forced along the sample, bursting the sheathing at a point beyond the screen. The screening was, therefore, an improvement, some of which might, however, have been due to mechanical reinforcement and the cooling effect of the metal.

Further experiments were, therefore, carried out in which the cable was lapped with tinfoil, over which was slipped a tube of vulcanised rubber. In the first experiment a 4-ampere arc was struck, and after about 5 minutes some smoke appeared and the leakage trip operated. There was no visible sparking. A similar experiment was carried out with a 20-ampere arc. The earth-leakage device operated in about 30 seconds, and although there was some smoke there was no visible ignition of the cable or discharge of flame. Had the outer sheath been continuous, it is doubtful whether even smoke would have made its appearance, and the current would have been cut off without any external evidence of a fault. From the above experiments it seems clear that screened cables are safer than unscreened cables from the fire standpoint. If, however, there is delay in operation of the earth-leakage trip it is still possible for core-to-screen arcing to occur. These conditions would be similar to those already described which have indicated that currents of the order of 4 amperes are sufficient to cause pronounced arcing and ignition of a standard rubber-sheathed cable if allowed to persist even for a few seconds. Increase in the intensity of the arc within the limits investigated does not seem more liable to ignite the cable; in fact, there are indications that with the higher current density the arc is more liable to be extinguished by the violence of the explosion when the sheath bursts. The present experiments suggest that any circuit-breaking device connected to the screen and set to operate almost immediately, or at any rate before the outer sheathing has burst, should be effective in preventing fire.

Argentine Petroleum Industry.—The total production of petroleum in the Argentine during 1939 was 2,959,186 cub. m. According to the *Monthly Journal* of the British Chamber of Commerce in the Republic, this figure represents an increase of 9 per cent. over the 1938 production.

THE DEMOLITION OF THE "MAURETANIA."*

By M. Wilkinson, B.Sc., M.I.E.S.

(*Concluded from page* 341.)

When cutting scrap steel, a burner has to clear away the paint by chipping in the way of his cut. However carefully this is done, when the torch is put through the steel, the surrounding paint and the paint on the back of the plate or angle burns. The lead vaporises, and the operator tends to breathe in the fumes, and becomes liable to lead poisoning. Weather conditions share in the incidence of lead poisoning. A close, moist, windless day makes the fumes hang in confined spaces and exposes operators to increased inhalation. Very careful medical inspection at regular periods helps to keep down cases of lead poisoning, but where a man shows susceptibility it is necessary to transfer him to other work. Masks are found to minimise poisoning, and the drinking of milk also helps. Masks, as designed up to the present, are uncomfortable to wear and hinder progress. A really effective light mask, which does not restrict vision or impede breathing, has yet to be offered to the industry. In the case of the Mauretania, the burners were given cocoa made with milk daily, and few cases of lead poisoning were encountered. These were very mild and were cured in their early stages.

In a passenger ship of the Mauretania type there are innumerable trunks and ventilating shafts running from top to bottom through the decks. When oxy-cutting operations are in progress, special care has to be taken, and it is necessary to trace out each trunk or shaft in the vicinity of the cutting, in case sparks are carried down them and set fire to some lower compartment or fall into oil-fuel bunkers. In the case of the Mauretania, this necessitated a systematic search and a constant watch by a fire party. In some cases it was impossible to trace the run of a trunk, and it was found effective to plug it with a bag containing wet asbestos from the scrap asbestos coverings in the engine room. A large hole was cut in the counter for mooring purposes. The oxy-acetylene torch proves invaluable in shipbreaking, and readily adaptable to such jobs. It is used for improvising openings in the hull for mooring and other purposes. Skips for lifting small articles and rubbish ashore are quickly made by cutting in half water-service tanks of suitable size.

The bottom half of the stator of the low-pressure turbine, which weighed just over 30 tons, had to be turned on its side in order to get it through the narrow opening that was available in the lower level of the engine room. The turbines were dismantled by removing the top halves, and then cutting through the rotor and dividing it into pieces convenient to handle. This entailed some very heavy cuttnig of the larger diameters of the rotor shafts. The cuts had to be made with the rotor in position and between the rows of blading. The blading was later driven out of the grooves of the rotor with pneumatic chisels. In some ships the blading is wired together with steel wire, and this has to be cut out in order to separate the blades, which are usually of phosphor-bronze in older ships. This is a laborious proceeding, but is justified by the extra value of the phosphor-bronze.

After the light superstructure had been swept off, it was necessary to attack simultaneously both the engine room and boiler room, as well as the clearing of the decks. If this were not done, too much weight would remain in the centre of the ship and the vessel would sag. The engine and boiler rooms presented no undue difficulty beyond their congestion, which was much the same as that of a warship. The engine room was remarkable owing to the very high specification to which all the machinery had obviously been made, a specification not exceeded by Admiralty practice. Whereas in the ordinary cargo vessel the minimum of non-ferrous metal is used, innumerable pieces of machinery, such as pumps, etc., were made mostly of non-ferrous metal in the Mauretania. The main steam expansion piece between the boiler and engine rooms was of copper where it passed through the bulkhead, and 75 in. in diameter. The ends of the main condensers were of good-quality gunmetal of very heavy section. Some of the piping was of exceptionally heavy copper, and the bends were examples of the skill of the coppersmiths who were employed on the construction of the ship.

The boilers were of the Scotch type, 23 double-ended and two single-ended. The tubes coming from this type of boiler are not of the small diameter found in water-tube boilers, and therefore do not command such a high price. If in good condition, however, they can be re-drawn for secondary tube articles, such as washing-green posts, etc. The plating from the Mauretania's boilers, owing to their size, was excep-

* Paper read before the Manchester Association of Engineers on Friday, March 15, 1940. Abridged.

tionally heavy, and was in such good condition that it was sold for re-rolling.

When the ship had been cut down to the main deck, she was lying against a straight granite quay. By this time she was riding high out of the water and her under-water portion was exposed. It was most remarkable to find that, in the 760 ft. of her length, she only touched the quay for a matter of 6 ft. Her lines showed the reason for holding the record for 22 years. The stern presented some problems owing to the fineness of the ship, and the large amount of weight without corresponding buoyancy. In order to get the vessel light enough to go round to the tidal yard, it was necessary to cut away the stern considerably. The stern was raised by flooding the fore end of the vessel and keeping the amidships part as light as possible and clear of loose water. The rudder head and bearing entailed some very heavy cuts. The stern was raised farther out of the water and the balanced rudder, which weighed 63 tons, had to have the top portion removed *in situ*. This left the bottom portion hanging on the rudder stock. The final lift of the bottom portion of the rudder was a very ticklish job, as the weight was something over 30 tons, and the crane was at a considerable outreach. The removal of the rudder allowed the stern to rise still higher, and the cast-steel stern frame and brackets for the two inboard propellers were cut up into sizeable pieces. The oxy-acetylene cutter severs cast steel with much the same ease as rolled steel. Cast iron, however, is a somewhat different proposition, and a specially designed tool is employed. The original weight of this frame was 104 tons. Here, again, very heavy cutting was required, the sections cut being between 1 ft. and 2 ft. thick. The outboard propellers were taken off while the vessel was in dock, and weighed approximately 16 tons each. This was accomplished when the boss came clear of the water, the propeller nut being removed and the propeller drawn off the shaft. In one case, difficulty was experienced in drawing the propeller and the shaft was cut through between the boss and the stern tube.

At this stage the vessel was removed from the dock and laid alongside a quay, but still kept afloat. Breaking-up operations were continued, gradually sweeping the decks down until the ship was cut down to lower-deck level at the ends, and main-deck level at the centre. In this position, alarming signs of flexibility of the hull became apparent. Forty-foot battens were placed on the deck, with their ends about a foot past each other. The other ends were fixed firmly to the deck. Pencil marks were drawn across the battens, which were free to move past each other. It was found that as weights were taken off the ship these pencil marks opened and closed by approximately a quarter of an inch. The battens proved a very valuable guide as to which portions of the ship to remove next, and an endeavour was made to keep the pencil marks in line, and to avoid unduly straining the remaining structure. At the outset as the decks were cut away, the vessel, from the side view, appeared to be cut in a series of steps, that is, as the cutting proceeded from amidships to the ends, it was stepped down a deck for about 100 ft. along, and then down again another deck, leaving a large amount of strength in the centre.

At the period when the battens were installed, it was found that the sharp angular contour of the cuts from one deck to another showed signs of cracking in the shell plates at the bottom of the angle. Thereafter the cuts were swept down from one deck to another in long diagonals or curves to avoid this. Further to lighten the ship, the bow was flooded again, and the tail shafts of the outboard propellers were drawn into the ship. The stern tubes were also cut off, and patches fitted over the openings. The vessel was finally cut down to the lower deck, leaving all the remaining bulkheads intact, and with the engine and boiler rooms completely swept clean. At this stage she had a draught of approximately 14 ft. forward and 10 ft. aft.

The tidal beach on which the ship was finally demolished was restricted for depth, and full advantage had to be taken of high-water spring tides in order to run the ship up as far as possible on to the beach, the rise and fall at Rosyth being in the region of 18 ft. at springs. The margins were so small that the berth had to be specially sounded and a plan drawn. It was decided to run the vessel up stern first, as once she took the ground it was possible that she might open up in any direction at the first low water, due to her great length and lack of remaining strength. It was essential that, should she open up, the heaviest weight should be under the cranes, of which there were three in number, of the ordinary derrick type. The vessel was towed the remaining few hundred yards without mishap, and beaching went according to plan.

Although cracks developed and certain sections of the ship lost their buoyancy, no undue difficulty was experienced in cutting off sections of the ship and floating the remainder up under the cranes successively. The procedure at the beach yard was for the top of the double bottom to be removed, the bottom being then marked off into convenient lifts of 10 tons. The double bottoms, as in most merchant ships, were heavily coated with cement, and a track had to be cut through the cement with pneumatic tools to enable the burners to cut right down through the bottom into the mud and completely sever the lifts. It was at this stage that the difficulty with residual oil fuel and oil sludge was most acute. The double bottoms were used for carrying oil fuel in service, as well as the side tanks. Before burning operations could be attempted, it was necessary to get rid of the sludge; in some cases by throwing in ashes and scraping it out; in others, the quickest method was to throw in old timber, and set fire to the oil residue. The men here worked under very dirty conditions, having to contend with oil residue, mud from the tide, and cramped spaces between the floors and the bottom. After each lift from the bottom came ashore, there still remained on it a large amount of concrete, which had to be removed. This was removed either by pneumatic tools, or by turning the section upside down on the ground and balling it with a large cast-iron ball dropped from a good height. The lifts were then finally cut up to market size.

The Mauretania was broken up by using oxy-cutting blowpipes for dealing with all mild steel and cast steel, with occasional cuts through larger pieces of cast iron. Hand blowpipes, of ordinary design, using medium-sized nozzles, were employed. Special blowpipes were used on comparatively few occasions, and then only for cutting through heavy parts at the stern or in the engine room. The consumption of oxygen per ton cut varied considerably, as was to be expected when undertaking work which ranged from light deck houses to heavy shell plating, and finally heavy bottom plate encrusted with rust, mud and oil. No accurate figure of oxygen consumption was kept, but from tests taken from time to time, the average lay in the region of 350 cub. ft. per ton of material, cut ready for the market. The output per man on a blowpipe also varies considerably according to where the man is working, material he is cutting, and his capabilities. A first-class operator working on good clean shell plating or boiler plating has no difficulty in turning out 6 tons to 8 tons of material a day, cutting lifts that have already been taken out of the ship, and reducing them to market size. The overall output for the total number of burners employed and the total steel in the ship, inclusive of cutting first to crane size and then to market size, lies more in the region of 2½ tons to 3 tons a day.

These figures were only obtained by giving the burners every facility, and oxygen and fuel gases were piped all over the ship; no cylinders whatever were used. The oxygen was led up the side of the dock in high-pressure pipes; it was then led on to the ship to a reducing valve and distribution box, and the burners were coupled on their individual lines of flexible hose to the distribution box. The pressure in general for the main part of the work was 120 lb. to 140 lb. per square inch at the reducing valve. This may appear high, but there was a considerable drop in pressure from the reducing valve to the cutting nozzle, due to long lengths of small-bore flexible pipe being trailed through the ship. The usual pressure actually delivered to the cutting nozzle was in the region of 40 lb. to 50 lb. per square inch. Again, this may appear high, but the general endeavour throughout the demolition operations was to keep up the speed of output. It was found that, though these high pressures have disadvantages, they enabled the burners to cut through dirty material and keep up their output rates. The Mauretania was broken up to a time-table. By this is meant that, before her arrival at the breaker's yard, a proposed time-table was forecast. The advantage of this lay in assembling personnel, disposing of the material by contract, and fitting in with operations running concurrently on other vessels being broken up. The vessel arrived at Rosyth in the first week of July, 1935, and the last lift came ashore at the beach yard in August, 1936: a total of 13 months. This is equivalent to an average output or rate of demolition of 500 tons per week, the maximum figure at the heaviest part of the hull being over 700 tons per week.

Several special items arose in the demolition. One was the salving of 20 tons of plate glass from rectangular windows and skylights and its re-sale abroad. Another was the lift shaft and grilles. When the vessel was built this item was much remarked on; it was a copy of ornamental ironwork, but due to the weight involved it was made of aluminium. This produced some 3 tons of aluminium, an item rarely found in ships. The non-ferrous metal was dealt with by a separate specialist department. It was sent to this department with the minimum of steel attachments as cut out of the ship. It was first separated from the steel, then classified and broken up. Much was disposed of, as arising, in its appropriate grade. Other categories were analysed and melted into ingots of guaranteed quality. There is no short road or scientific method in the recovery of non-ferrous scrap. It is done by hard manual labour and hammer and chisel. Pneumatic tools—chisels and drills—facilitate matters. Pneumatic wrenches have been tried for unscrewing nuts, but without success. The difficulty lies in starting an old rust-encrusted nut, the maximum effort being required initially—the reverse of the pneumatic wrench's operation on new work.

Classification is done by eye, feel, and chemical analysis. Testers are craftsmen of long years of experience. An expert tester will unerringly classify small pieces of copper, brass, phosphor-bronze, manganese-bronze, etc., per day merely by colour, a quick rasp with a file, or chip off a corner with a hammer. Two important considerations in shipbreaking are adequate cranage and proper supply of gases to cutting operators. The cranage has to be so balanced that the maximum output from the ship afloat or at a tidal yard is rapidly distributed to burners on the shore and loaded for dispatch. It is essential to keep down congestion, as the awkward shapes arising in demolition do not allow of tidy stacking. The conditions were fulfilled in handling the Mauretania, and contributed to the rapid disposal of the ship.

FIFTY YEARS OF MARINE ENGINEERING.*

By PROFESSOR A. L. MELLANBY, D.Sc., LL.D.

(*Continued from page* 328.)

IN the earlier part of this lecture mention was made of the supposed importance of dividing the total temperature range equally between the three cylinders of a triple-expansion engine and of the beneficial effects that were supposed to arise if this could be attained. It is difficult to appreciate the reasons for this belief, but it was strongly held and had a great influence in the cylinder proportioning and the power distribution among the different cylinders. The strange thing is that the amount of surface exposed to the steam appeared to be taken very little into account, although it was obvious that the surface exposed, up to cut-off, to the influence of the entering steam would be much greater in the low-pressure than in the preceding cylinders. It is, however, worth noting that in the discussion on Mr. Wyllie's paper (1886) it was pointed out by Professor Ryan that it was not proved that inequality in range of temperature caused any large amount of evil through condensation and also that initial condensation depended not only upon the temperature range, but also upon the amount of surface exposed to the steam.

As to the changes in practice that have resulted from experimental research, the problem of number of expansions was conclusively settled by the first series of tests carried out by Professor Weighton upon his experimental engine. The tests were made with the engine working with quadruple expansion under a boiler pressure of 210 lb. per square inch and with power development varied by changing the number of expansions of the steam. Some of the results obtained are shown in Fig. 1, page 372, the important conclusion to be drawn from this diagram being that the curve of steam per brake horse-power hour shows that, within the limits of the trials, a minimum value has not been reached and that for maximum efficiency an even higher value of mean effective pressure than about 35 lb. per square inch might have been used. The author emphasised that the practical lesson taught by the tests was that engines should be made small for the power developed, and estimated the dimensions of two quadruple-expansion engines with specified power, pressure, and speed conditions, one designed for a mean effective pressure of 20 lb. per square inch and the other with this pressure raised to 35 lb. per square inch. Under the first condition the diameter of the low-pressure cylinder would be 71 in. and under the second condition it could be reduced to 52 in. In addition, the smaller engine would require 6½ per cent. less steam than the larger one and consequently the boiler size could also be correspondingly reduced. In the discussion which followed there appeared to be a general agreement that the results represented facts and that old ideas upon efficiency and mean effective pressure would have to be changed. Such a readjustment of ideas has been made and the information available from the trials has had a profound effect upon marine practice. Those interested in this question of mean effective pressures are recommended to refer to a paper written by Mr. R. Royds (1906-7) where they will find much valuable information upon efficiency under varying steam expansions.

* The twelfth Thomas Lowe Gray Lecture, delivered before the Institution of Mechanical Engineers on Friday, March 15, 1940. Abridged.

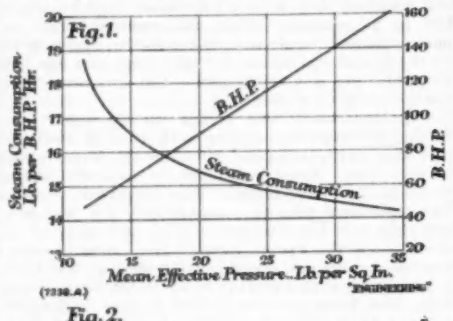
A further point of interest to marine engineers of fifty years ago was the proportioning of the power developed between the different cylinders of a multiple-expansion engine. A second set of trials made in Newcastle produced results that enabled the fixing of cylinder proportions and power distribution in multiple-expansion engines to be put upon a sound design basis. The account of these trials will be found in a paper by Professor Weighton (1899-1900) entitled "Receiver Drop in Multiple-Expansion Engines," where are described experiments made to determine the most economical point of cut-off in the larger cylinders of multiple-expansion engines. Some idea of the nature of these trials will be obtained by an examination of Fig. 2. The rise and fall of the brake horse-power developed by the engine is well illustrated, and notice should be taken of the continual rise in steam consumption as the point of cut-off is made later. Any difficulty in appreciating why, under such conditions, the steam consumption will alter will disappear when it is appreciated that with later cut-off in the intermediate-pressure cylinder the back pressure in the high-pressure cylinder will fall. Similar results were obtained by varying the point of cut-off in the low-pressure cylinder, although, as might have been anticipated, the increase in steam consumption with later cut-off is less marked. By using different cylinder ratios, as was possible with the four cylinders at his disposal, Professor Weighton was able to obtain an expression from which could be calculated the most efficient point of cut-off in any cylinder after the high-pressure one for any multiple-expansion engine, and the results could also be used for making a very close approximation to the best ratio of cylinders for any predetermined total number of expansions. These experiments disposed, once for all, of the notions that maximum economy was associated either with equality of power development or with equality of temperature range in the several cylinders.

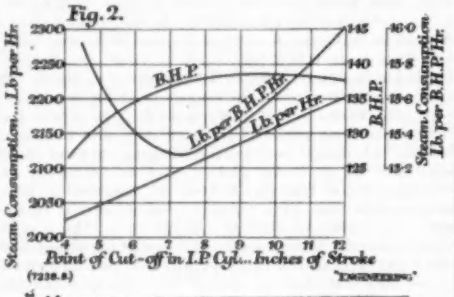
On the subject of initial condensation, it may be assumed that the early success of Watt through introducing the separate condenser, and thus avoiding the admission of steam to a cylinder that had just received a violent cold-water spray, had deluded many people into the belief that still further great improvements could be attained by diminishing the loss due to the temperature rise and fall of the working steam alone. Obviously, if steam entering a cylinder is condensed, it is because the surface of the metal with which it comes into contact is below saturation temperature. The cooling of the metal results from contact with the steam during expansion and exhaust, so that there will be a cyclical rise and fall of temperature of the cylinder surface just as there is a cyclical rise and fall of the steam temperature and pressure. The difficulty that arises is to determine the range of the metal temperature. Originally, it appears to have been believed that the surface temperature of the cylinder walls followed closely that of the steam, and a number of people still hold this idea. If it were true, the steam consumption of engines would be enormous.

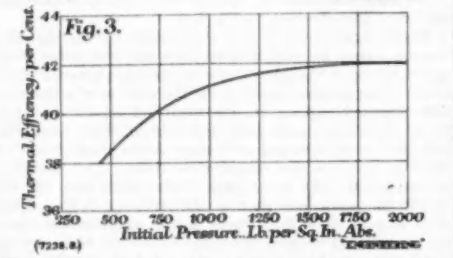
The real solution of the problem was given in a paper presented to the Institution of Civil Engineers by Callendar and Nicolson (1897-8). There it was shown that the cyclical temperature fluctuation of the metal surface was nothing like that of the steam and that under all normal circumstances it was so restricted that it could be responsible only for a small proportion of the "missing quantity." From this it followed that the difference between indicated and actual weight was due to initial condensation plus valve leakage and that in the majority of engines using saturated steam the latter was by far the greater of the two. It is surprising that this paper is now so little appreciated and that the belief is still prevalent in some quarters that in many engines something between 30 per cent. and 40 per cent. of the steam present in the cylinder at the point of cut-off is in the form of water. Even in some fairly modern text-books absurd analyses are made of heat exchanges between cylinder walls and steam based on the assumption that the steam in the cylinder is a constant quantity, while the temperature-entropy diagram is used to show entirely wrong estimates of the condensation and re-evaporation during expansion. I submit that the experimental work to which I have referred has placed the marine-engine builder in a much more satisfactory position.

Condensers.—The design and operation of the condenser greatly influence engine power development and efficiency. Fifty years ago little attention was given to the design of a condenser, the amount of condensing surface being generally fixed by apportioning so many square feet to each horse-power developed by the engine. The temperature of the air-pump discharge was, as a rule, well below that of present-day practice with corresponding condenser pressure, and the usual practice at sea was to carry a vacuum of 25 in. to 26 in. of mercury. This, with its correspondingly fairly high temperature of condensate, was supposed to represent conditions of maximum efficiency. Consequently, the engines were not designed for high-vacuum conditions and the drop of pressure between cylinder and condenser for vacua of 26 in. of mercury and over was fairly serious. It was in the 1900's, and largely through the successful operation of the steam turbine, that general attention began to be directed towards the surface condenser. Especially did stress begin to be put upon the fact that air in the condenser had a great influence upon performance.

The first set of systematic experiments upon surface condensers, of which I know, was carried out at Newcastle by Professor Weighton, using the engine plant to which I made previous reference. A description of the tests will be found in his paper presented to the Institution of Naval Architects in 1906.* The water of condensation was removed from the tube spaces at several stages of the condensation process; the usual steam space at the top of the condenser was removed and in its place was substituted a passage of shape and section designed to distribute the entering steam over the whole length of the tubes; the section of the condenser was so proportioned as to promote uniformity of steam flow over the whole tube surface.







The tests were made of special interest by comparing the performance of the new design of condenser with that of the condenser originally supplied with the engine. This followed the conventional design features of marine condensers of those days and was a fair representation of standard practice. The most striking feature disclosed by the tests was that the new type of condenser, with 62 sq. ft. of surface, was capable of maintaining the same vacuum under similar steam conditions as the old condenser with 170 sq. ft. of surface. The amount of circulating water used with the new type was also appreciably reduced since it was found possible to hold the same vacuum with a higher outlet temperature of circulating water. In all tests air leakage was reduced to a minimum and the same air pump was used for both old and new types of condenser. Since the publication of this paper much greater attention has been given to condenser design, and, especially in marine installations, great savings of weight and space have been made.

When once attention had been directed towards the pernicious influence of air in the condenser, greater care was given to the means of minimising its entry and of extracting it, and vacuum production was placed upon a much more scientific basis. One of those most prominent in bringing about this improvement was the late Mr. D. B. Morison, and arose from a paper he presented to the Institution of Naval Architects in 1908 and one presented to the North East Coast Institution of Engineers and Shipbuilders (1910-11). Much discussion arose from this latter paper, but from 1910 onwards the proper use of feed heaters and the economical disposal of auxiliary exhaust steam received ever-increasing attention. Feed heaters supplied with heating steam direct from the boiler have for long been a standard part of a marine installation. Used thus, they obviously do not increase the efficiency of the plant since the heat absorbed by the feed in the heater is no less than would be given to it if pumped into the boiler direct. Experience had shown, however, the evil effect of delivering cold water into the ordinary Scotch boiler, so the introduction of the high-pressure steam feed heater may be looked upon as a means of keeping down boiler troubles.

But there had been a proposal many years before to use feed heaters in stages and this it will be seen offered not only the possibility of high-temperature feed water, but also the attraction of a reduction in fuel consumption. To understand this it is necessary to make a very brief reference to the Stirling regenerative cycle as introduced by the Rev. Robert Stirling, parish minister of Galston, near Kilmarnock, in 1827. In this cycle the outstanding feature is that the temperature of the working substance is raised from its minimum to its maximum value by withdrawing heat from itself during expansion. Somewhere about 1887 it was proposed by the late Mr. J. Weir to Professor Cotterill that some approach to this cycle might be obtained by using what is now known as stage feed heating. A full discussion of the principles of stage feed heating and the gains in efficiency to be expected from its adoption in compound, triple-, and quadruple-expansion engines are included in a paper given by Professor A. C. Elliott in 1895 to the South Wales Institute of Engineers.* Very little attention was given to the application of this method of feed heating to marine installations until comparatively recent times, but on land the principle has been widely adopted, while some modern marine engines have employed stage feed heating to a somewhat remarkable degree.

Steam Turbines.—We are fortunate in having in our *Proceedings* the Parsons Memorial Lecture by Mr. Stanley S. Cook†, and in it will be found a full account of the initiation and development of the marine steam turbine by one who was associated with Sir Charles Parsons over a long series of years. Any detailed description would, therefore, be out of place here, but, though much doubt at first existed, by 1904 all prejudices and fears appear to have been overcome, for it was then decided to equip the liners Lusitania and Mauretania with Parsons turbines. Since in each vessel a shaft horse-power of 70,000 had to be developed, it will be recognised how great was now the confidence in the reliability of the turbine drive. Similar strides had been made in the application of the turbine to naval vessels and at about this time an order was placed for turbine machinery for the battleship Dreadnought.

The success attained by the turbine in vessels of high speed and those requiring large power directed attention to the possibility of its use in vessels of moderate speed and power. The low speed of revolution necessary for an efficient propeller, and the high blade speed required for the efficient use of the steam, necessitated a compromise from which it was impossible to obtain the best results. In vessels such as the Lusitania and Mauretania when the speed of the propeller shaft and of its direct-coupled turbine, fixed from propeller considerations, was 180 r.p.m., the diameter over the blades of the low-pressure rotor had to be made as much as 15 ft. 4 in. on account of the high velocity generated in the expanding steam. The necessity for some speed reduction system was obvious, and toothed-wheel gearing naturally suggested itself, especially as such a system had been successfully employed on de Laval turbines on land for some years. Experiments had also been made by Parsons in 1897 with a turbine in a small launch with single-reduction helical gearing for a speed reduction of 14 to 1. There was, however, a great difference between the employment of gearing in such small examples and its application to marine propulsion, so Parsons undertook a large-scale research by fitting a turbine with single-reduction gearing into the cargo steamer Vespasian. The success of this installation, when about 1,000 shaft horse-power was transmitted from a turbine shaft with two pinions of 5 in. diameter to a double-helical gear of 100 in. diameter on the propeller shaft, was such as to attract the attention of shipowners and marine engineers, and gradually geared turbines were applied to vessels of almost every class. By about 1917 double-reduction gearing was introduced and the application of the turbine drive to ships of moderate speed became greatly increased. Meanwhile turbines of types other than that of Parsons had been developed, so that steamships of to-day may be driven by turbines of the reaction or impulse types, or by combinations of the two systems.

It might be argued that the troubles and failures of early turbine practice generally originated in constructional form and details, conditions of operation,

* See ENGINEERING, vol. 81, page 479 *et seq.* (1906).

* See ENGINEERING, vol. 59, page 62, *et seq.* (1895).

† *Loc. cit.*, vol. 146, page 680 (1938).

weakness of material, and in the general dynamic effects created by the enormous speeds at which action in a steam turbine takes place. Some of the effects due to these high speeds could not have been foreseen and indeed when they became evident the result was to compel a new study of the theory of rigid dynamics and to show that some of the finer issues of the theory of vibrations had a definite place in engineering design. In fact, the value of the scientific mind to engineering progress became particularly evident during the development stage of the turbine, and problems were solved with mathematical equations that might have taken generations to overtake with trial and error methods. An early trouble was distortion arising from irregular heating in starting up; from uneven temperature variation in running; from sudden temperature changes due to alteration of load; or from a restricted freedom for necessary expansion. To the general public, news of failures due to distortion is generally derived from accounts of accidents on large land turbines, but they had been experienced twenty-five years ago or so with large direct-coupled marine turbines. Blade rubbing or stripping, loose wheels, local heating resulting sometimes in a bent spindle, have all been experienced. It says much for the designer and operator that distortion troubles are no longer the nightmare they once were.

The problems of turbine construction have given a great impetus to the study of materials, more particularly to those non-ferrous metals and alloy steels suitable for blading. For casings, cast iron is the usual material so long as the temperature conditions are moderate. It was found at an early stage that for temperatures above 450 deg. F. troubles from growth and deterioration might arise with the type of cast iron then available, so for the higher temperature limits cast steel is the material in common use. It is, however, with the blading that the quality of materials is most severely taxed. Two main tendencies are evident in the evolution of blade material. One of these arose from the desire to avoid corrosion by the use of non-ferrous blades that weaken at high temperatures, and the other from the compulsory employment of high-tensile steels that were actually corrosive. A non-corrodible metal is required that can withstand the action of high-speed high-temperature steam jets when it is being subjected to severe steady stress, repeated bending stress, and probably vibratory stress. It has also to lend itself to ready methods of manufacture and such as will ensure freedom from surface cracks or internal defects. The specification is one that is difficult to fulfil, but such progress has been made that to-day failures are relatively rare. A very strict specification is demanded by the conditions under which blading has to work. Instead of the perfectly continuous and regular steam action commonly conceived, it must be realised that any particular blade is changing its disposition relative to the operating jet with great rapidity and that the blade must undergo cyclic changes of force in the course of a revolution, if there should be any irregularity of jet distribution in the nozzle circle. There are cases in which this irregularity is deliberately created by partial admission or by nozzle governing, but apart from these, there must be in any jet arrangement certain minor disturbances sufficient to produce rhythmic variations in the action. Thus we have the steady centrifugal stress, generally severe due to the very high blade speed, acting along with varying stresses due to load transmission and possibly repeated stresses due to vibration. In addition, there are possibilities of erosion caused by solid particles in superheated steam, and water particles in saturated steam, and of corrosion due to the humid internal atmosphere during periods of rest.

Consideration must also be given to the possibilities of vibration of the blade wheels or discs. At one time serious turbine wrecks were distinctly traceable to the weakness of disc wheels under the vibratory stress arising out of synchronism between some natural mode of vibration and an impressed rhythmic force of high frequency. Wheel vibration is a much more complex matter than blade vibration, but its results are similarly manifested in fatigue failures. The investigation of such vibration is of great theoretical difficulty; and much mathematical skill and ingenuity has been expended upon it. A large amount of experimental work has also been devoted to it, with electrical devices designed to vibrate the discs both when stationary and revolving. As a result of such research over a series of years, manufacturers can now design their discs with a reasonable feeling of security.

The most advertised difficulty in the development of turbine propulsion was that connected with gearing, where the alarming feature was that the failures encountered developed long after what might have been considered as the probationary period. With gearing there was no definite point of view and no one was prepared to state that failures had been traced to some fundamental fault. Some engineers blamed the steelmakers for the quality of the material provided for wheels and pinions, while others put down all the troubles to torsional oscillations. Pitting was attributed to the failure of lubrication at the instant of pure rolling action and brought as a reply that, at this point, lubrication was most effective. Added to those were discussions dealing with the respective merits of floating and rigid frames, tooth loading, tooth and alignment faults, and excessive bearing clearances.

Single-reduction gears had been built in large numbers for naval vessels and were fitted in quite a large number of merchant ships. Only in very few cases had they given trouble and there was very little doubt regarding the reliability of the system. Double-reduction gears when introduced were essentially a fitting for merchant ships, and by 1918 the tendency to use them had become very pronounced. An early article appeared in ENGINEERING* in 1920 referring to difficulties experienced with gearing and developing the film breakdown theory. During 1920 and 1921 the floating-frame versus rigid-frame controversy developed, in which the merits of the former were ably sustained by McAlpine. But it was after the presentation of the two papers by Smith and Wilkie† before the Institution of Naval Architects in 1922 that the real controversy began. It was carried through 1922 and 1923, specially marked by fierce discussions on dynamic matters between a special few, while other contributors wandered all over the field of materials, accuracy of cutting, periodic errors, fitting, and lubrication.

A brief outline of the experiences of the s.s. Melmore Head may serve to bring home to the younger members some idea of the seriousness of the problem. In this vessel, altogether, three sets of gearing were fitted in the original gear cases and all three proved equally unsatisfactory. Noise in the engine room showed that the teeth were hammering each other in a manner which soon produced excessive wear with heavy pitting and grooving and continual choking of the oil filters with steel particles from the teeth. Vibration of the gear-case with its pipes and fittings was also a serious source of trouble, and gave rise to frequent breakages of the oil pipes, with loss of oil and consequent menace to the safety of the ship. The first set of gears collapsed through excessive wear and the development of heavy end movement of the pinions after completing 25,000 miles. In the second installation the hammering of the pinion fractured the second-reduction gearing, stripping all four pinions and the main wheel after running 14,000 miles. The third set were only prevented from hammering themselves to destruction by reducing the speed of the ship from 11 knots to 7 knots.

At this time, Professor J. H. Smith, of Belfast, was consulted and after examining the system he came to the conclusion that the trouble was caused by torsional oscillations set up primarily by periodic action arising from the propeller blades. He conceived the notion of varying the flexibility of the shafts connecting the turbines to the primary pinion so as to bring the node in the oscillating system to the gearing, thus inventing what became known as the "nodal drive." The changes to the nodal drive were made with gratifying results. The immediate effect was to eliminate the hammering in the gear case and the vibration in the pipes and fittings and when Mr. Wilkie's paper was read the ship had completed 100,000 miles at full speed with the third set of gears without the slightest trouble. For some time the nodal drive became popular and a number of ships fitted with the gear gave satisfactory service. But those who think that the success of Professor Smith convinced his critics of the correctness of his nodal-drive theory should read the discussions on Mr. Wilkie's paper and the subsequent controversy in the technical journals. After 1923 the controversy died down and little has been heard since then of gear trouble.

In addition to the gear speed reduction system, two other methods of obtaining maximum efficiency at both turbine and propeller have been introduced. One of these, the hydraulic speed-reduction system, contains a centrifugal pump and a hydraulic turbine, with the pump coupled directly to the steam turbine and the hydraulic turbine to the propeller shaft. The system was introduced by Dr. Föttinger in 1907 and a good many vessels, mainly German, were fitted with it by 1914. The other system is the electric speed-reduction method, in which the high-speed turbine drives an electric generator which supplies current to slow-speed motors connected directly to the propeller shaft. The late Mr. Henry Mavor presented a paper (1907-8) to the Institution of Engineers and Shipbuilders in Scotland describing a new method of electric drive. His proposals involved the use of multi-phase induction motors from which different speeds could be obtained by the use of more than one rotating member. The first test of the equipment was made on the Clyde in 1911 with a 50-ft. launch named the Electric Arc. A second experiment was made in 1913 on the Tynemount, a vessel 250 ft. long, in which the driving power was supplied by two Diesel engines each developing 300 brake horse-power at 400 r.p.m. Due largely to lack of power, the trials, when under full load, were not altogether satisfactory, but the squirrel-cage motor and the simple switch control gave the smooth working and prompt response which had been hoped for. At about the same time trials with electrically-propelled ships were being made both in America and on the Continent. In America, special interest was taken in the scheme by the United States Navy and several battleships and battle cruisers were electrically equipped. To-day, the electrical transmission system is, however, to be found in all classes of ships, including liners, cargo boats, oil tankers, and tugs.

(To be continued.)

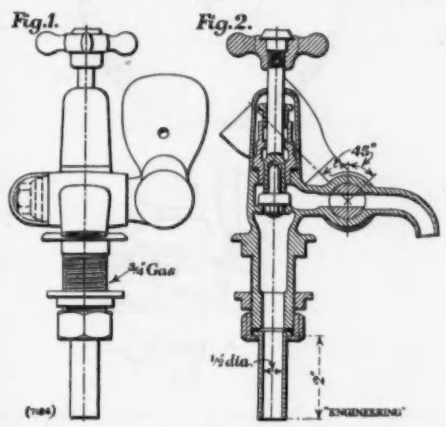
* ENGINEERING, vol. 109, page 599 (1920).

† *Loc. cit.*, vol. 113, page 438, *et seq.*, and page 569 (1922).

COMBINED WATER TAP AND DRINKING FOUNTAIN.

SECTIONS 41 and 42 of the Factories Act, 1937, provides that, in addition to facilities for washing, supplies of drinking water shall be available in all workshops and factories. Even where the washing water is of a quality suitable for drinking, it has been usual to provide separate taps for drinking purposes, to avoid risk of contamination, and latterly the practice has spread of arranging convenient drinking fountains in the shops themselves. In such cases, the Home Office preference is for the type with an upward-discharging jet, with which no separate drinking vessel is necessary.

To avoid the need for a second tap, where washing and drinking facilities are closely adjacent, Messrs. Glenfield



and Kennedy, Limited, Kilmarnock, have designed the combined tap and drinking fountain, illustrated in the accompanying elevation and section, which complies with the regulations and also with the desire of the Home Office to dispense with separate cups. The device consists of a polished gunmetal tap, the plug of which is provided with an additional port (not visible in the plane of the section, Fig. 2) communicating with the drinking fountain. In the position shown, the water has a free passage to the outlet for washing purposes. A movement of the fountain bowl through 90 deg., as indicated, cuts off the washing water and directs the flow to the drinking jet. It will be seen that washing water cannot be obtained until the fountain bowl has been pushed back, well out of the way of any contamination. Particular care has been taken in the design to eliminate joints and crevices in which dust might lodge, so that the fitting can be kept clean with a minimum of trouble. As stated, the taps are normally polished all over; if desired, however, they can be supplied chromium-plated. They are clearly marked "Drinking Water," in accordance with the Home Office regulation.

NEW YORK POWER SHOW.—The 14th biennial National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace, New York, U.S.A., from December 2 to 7.

LAUNCH OF THE M.S. "STOCKHOLM."—The 28,000-ton motor liner Stockholm, built for the Swedish-American Line, was launched at the Monfalcone Shipyard, Italy, on March 11. A vessel of the same name was completely destroyed by fire at Monfalcone, in December, 1938, when its construction was almost complete. The new ship is similar in appearance and dimensions to the one lost by fire.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification in each case, is given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

517,370. Resilient-Wheel Undercarriage. R. H. Bound, of Cheltenham. (5 *Figs.*) May 27, 1938.—The object of the invention is to effect a saving of weight and cost, and simplify the construction of undercarriages in which the wheels are mounted on shock-absorber units. The undercarriage, which is rigid, consists of a pair of legs cross-braced to form a frame. The ends of the legs are forked and embrace a pivoted lever 2 and link 3. The lever has an internal cylinder 4 offset in relation to the pivot of the lever. In the cylinder slides

Fig. 1.

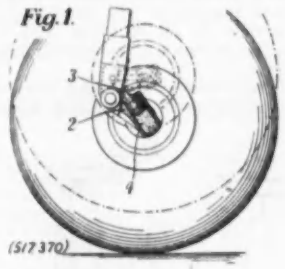
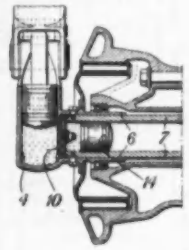


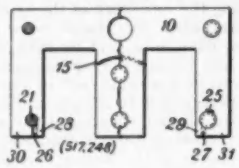
Fig. 2.



a shock-absorber piston connected to the outer end of the link 3 by a gudgeon pin. The cylinder 4 is filled with oil, and when the lever 2 is moved upwards the piston and cylinder act as a shock-absorber unit. The lever 2 has a lateral socket 6 (Fig. 2), in which is secured a tubular spindle 7. In the end of the spindle is a plate 10 carrying ports and a check valve. A duct connects the outer end of the cylinder 4 with the socket 6 and plate 10, through the ports in which oil can flow under the control of the check valve. Within the cylinder formed by the spindle 7 is a pair of idle pistons 14 separated by compressed air. The spindle thus interconnects the shock-absorber units. Upon the sockets 6 are bearings for the landing wheel and the non-rotating parts of the wheel brakes. To remove the wheel, the pivots of one lever 2 and link 3 are withdrawn and the socket is removed from the spindle, the bearing and brake parts on that side coming away with it. The wheel can then be removed. All parts can be standardised and are applicable to aircraft of different types. Moreover, the pressure in the twin shock-absorber units must be uniform, since it is dependent on the pressure of the air between the pistons 14. (*Accepted January* 29, 1940.)

ELECTRICAL APPARATUS.

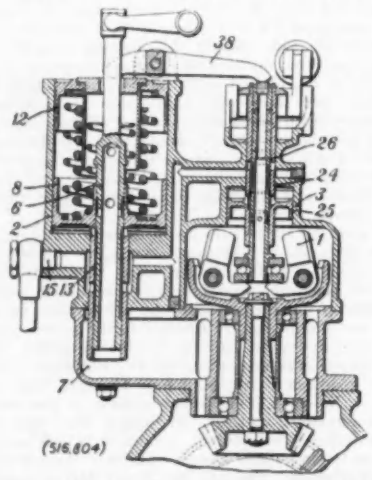
517,248. Electromagnet. The British Thomson-Houston Company, Limited, of London. (5 *Figs.*) August 31, 1938.—The invention is an electromagnet having a reliable, strong and low cost magnet core structure, with increased contact area between the pole faces and the armature. Heretofore the air gap, for ensuring, when the magnet coil is de-energised, a decrease in residual flux to a low value at which the armature will be released, has been provided between the armature and one of the pole faces and consequently the face of the remaining leg only is subjected to the impact of the armature. The stationary portion 10 is formed with the faces or ends of its three legs in alignment with each other so as to be mechanically engaged by the movable armature of the core. An opening 15 is provided forming an air gap in the middle leg at some convenient distance from the end of the leg, the laminations being assembled so that the slots are in alignment and form the air gap. To facilitate assembly, a layer of electrically insulating material is provided in the slot which properly spaces the end portions of the laminations. The assembled laminations are clamped together between two side plates of brass having the same configuration as the laminations, the side plates being held together by rivets. By locating the rivets 21 and 25 in the positions ordinarily occupied by the pole shader and making these rivets of electrically-conducting material such as copper or brass, a strong and efficient pole shader is formed with the plates. Slots



26 and 27 are provided in the ends of the two outer legs of the laminations in the positions where slots ordinarily are provided for the conventional pole shaders. The bottoms of the slots are enlarged to provide apertures for the rivets 21 and 25. It is necessary that these rivets be in good electrical contact at their ends with the plates in order to provide a conducting closed-circuit pole-shader loop. Welded, brazed or soldered joints are, therefore, formed at these points. The magnetic fluxes in the inner portions 28 and 29 of the core complete their magnetic circuits inside the pole-shader loop formed by the two side plates and rivets 21 and 25. In other words this flux does not interlink the pole shader and hence is not shaded. On the other hand, the fluxes in the outer portions 30 and 31 of the core interlink the pole shader and therefore are shaded. (*Accepted January* 24, 1940.)

INTERNAL-COMBUSTION ENGINES.

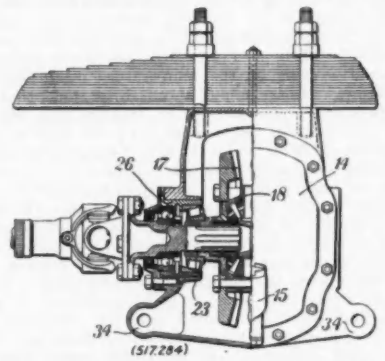
516,804. Engine Governor. Davey, Paxman and Company (Colchester) Limited, and E. P. Paxman, of Colchester. (2 *Figs.*). July 8, 1938.—The governor is of the servo assisted type for controlling the fuel pump of an internal-combustion engine. Manual control of the governor weights 1 is exercised through an oil servo device in a cylinder 2, while the governor variations due to engine speed fluctuations are transmitted through a servo device in a cylinder 3 to a fuel-pump rack. The manual control is through a spindle integral with a hollow ported sleeve valve 6. Surrounding the sleeve valve 6 is a piston 8, loaded by three springs, the upper ends of which bear successively against an upper floating piston 12. The piston 8 is integral with a ported sleeve 13. Oil from the lubricating system is fed in at 15, and the sleeve 13 and valve 6 control its flow to and from the cylinder 2. The oil inlet is also connected to ports in a sleeve 24, formed integral with a piston 25 in the second servo cylinder 3. Within the sleeve 24 is a hollow valve 26, having a necked portion, which, in conjunction with a counterbore in the sleeve 24, allows oil to enter the space above the piston 25. The valve 26 also has ports through, which oil can escape.



The base of the sleeve valve 26 rests upon a ball thrust race supported by the governor weights 1. The upper end of the piston sleeve 24 is connected to the control rack of the fuel pump. The top end of the sleeve valve 26 is engaged by one end of a lever 38 bearing at its opposite end upon the top of the floating piston 12. In operation, when the engine speed falls, the governor weights 1 move inwards and the valve 26 moves down. The necked portion of the valve then allows oil to flow to the space above the piston 25, forcing it and the sleeve 24 down until the oil supply is cut off by the counterbore on the sleeve. The downward movement of the sleeve 24 also operates the control rack of the fuel pump to admit more fuel. When the engine speed rises, the weights move the valve 26 upwards, connecting the space above the piston 25 with the oil reservoir and leaving it free to rise under the action of a return spring on the fuel pump. To increase the speed of the engine, the manual control raises the spindle and valve 6, allowing oil to flow into the base of the cylinder 2 and force the piston 8 upwards. The floating piston 12 is lifted, rocks the lever 38, and depresses the valve 26 until its lower end bears on the weights 1 and forces them inwards. The effect is thus the same as a decrease in engine speed. The reverse operation of the manual control exhausts oil from above the piston 25 and allows it to rise under the action of the fuel-pump return spring. (*Accepted January* 1, 1940.)

MOTOR ROAD VEHICLES.

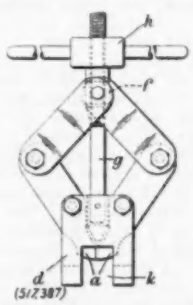
517,284. Differential Gear. Alvis, Limited, of Coventry, A. A. Sykes and L. Bradley, of Coventry. (2 *Figs.*) July 15, 1938.—The object of the invention is to produce a one-piece differential gear and housing which can be used in independent suspensions where a transverse leaf spring is bolted to a flat top of the housing The opening of the housing through which the main portion of the gearing is inserted is opposite the opening for the input shaft and is closed by a detachable cover 14, which also carries the oil filler plug 15. The main portion of the gearing consists of a crown wheel 17 bolted to a



built-up driving casing forming a carrier 18 for the planet pinions which are in mesh with a pair of sun wheels. The driving casing has sleeves 23 journaled in taper-roller bearings mounted in sleeves 26 which are inserted into the housing from the outside and are bolted through flanges to it. These sleeves also carry ball bearings for supporting the output shafts which are inserted from the outer ends and have splines to engage internal splines in the hubs of the sun wheels. The output shafts terminate in flanges bolted to universal joints through which the drive is transmitted to the swinging half axles. The top of the housing is flat to take the transverse leaf spring. Lugs 34 on opposite sides of the casing and low down take the transverse suspension links. (*Accepted January* 25, 1940.)

MISCELLANEOUS.

517,387. Battery-Repairing Tool. Joseph Lucas, Limited, of Birmingham, and S. J. Hinks, of Birmingham. (2 *Figs.*) July 26, 1938.—The tool is for use in cutting the lead posts which form part of the connectors between the cells of a battery so that damaged plates of one cell can be removed without disturbing the plates of other cells. Cutting blades *a* are formed on the ends of a pair



of links which are pivoted on a metal support *d*. At their other ends the links are pivoted to another pair of double links, the other ends of which have a common pivot on a slide *f* carried on a rod *g* which extends from the support *d*. A nut *h* is threaded on to the upper end of the rod and engages with the upper surface of the slide *f*. By screwing down the nut the cutting blades are pressed towards each other. By unscrewing the nut, and pressing together the pairs of links, the blades are retracted. The support *d* has a slot *k* to accommodate one of the posts on the plate connectors of a battery so that when the cutting blades are forced together across the slot *k* they sever the post within it. (*Accepted January* 29, 1940.)